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HANDBOOK FOR THE REVIEW OF AIRPORT ENVIRONMENTAL IMPACT STATEMENTS

by

Kenneth E. Nelson and Sarah J. LaBelle

ARGONNE NATIONAL LABORATORY

ENERGY AND ENVIRONMENTAL SYSTEMS DIVISION

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July 1975

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ABSTRACT

The principal objective of this report is to supply airport planners and reviewing agencies with guidelines for the technical review of airport environmental impact statements. The guidelines contain both procedural and technical guidance for the comprehensive review of air, noise, water and wastewater, solid waste, land use, hazardous materials, and ecological impacts.

The report includes discussion of the evaluation of environmental impact statements and the airport development process. A classification system was developed to rank projects according to their impacts. The major thrust of the report deals with assessment techniques for airport-generated pollutants. This includes a discussion of standards and procedural guidelines, the identification of sources, and evaluation of state-of-the-art assessment techniques, and description of abatement strategies. Finally, the assessment for the overall airport project used by the EPA, along with an explanation of viable alternatives to an airport project, is presented.

1.0 INTRODUCTION

On January 1, 1970, the National Environmental Policy Act (NEPA) was enacted.[1] Section 102 of the Act requires the preparation of environmental impact statements (EIS) by federal agencies on proposals for legislation and other major federal actions that will significantly affect the quality of the human environment. Federal agencies preparing the statements are required by NEPA to make the statements available to the President, the Council on Environmental Quality (CEQ), which was established by the Act, and the public. Furthermore, prior to preparing the EIS, the responsible federal official is required by the Act to consult with and obtain comments from any federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved.

Executive Order 11514, issued by the President on March 5, 1970, required the Council on Environmental Quality to issue guidelines for the preparation of environmental impact statements. On April 30, 1970, interim guidelines were issued. During the same year, various departments and agencies within the federal government were organized into one agency. On December 2, 1970, the Environmental Protection Agency (EPA) was officially established.

The Clean Air Act[2] was then enacted on December 28, 1970. Section 309 of this Act gave EPA the legal mandate to review and comment, in writing, on the environmental impact of any matter relating to its duties and responsibilities as contained in (1) legislation proposed by any federal department or agency, (2) newly authorized federal projects for construction and any other major action to which NEPA applies, and (3) proposed regulations published by any federal department or agency. Section 309 further states that any legislation or action found by the EPA to be unsatisfactory in regard to public health and welfare and environmental quality will be referred to the Council on Environmental Quality by the administrator of EPA.

Interim procedures for the implementation of Section 309 of the Clean Air Act were issued by the Council on Environmental Quality on April 23, 1971. The procedures directed federal agencies involved in actions related to air or water quality, noise abatement and control, pesticide regulation, solid waste disposal, or radiation criteria and standards to submit, for review and comment by EPA, proposals for new federal construction projects and other major federal actions to which Section 102 of NEPA applies, and proposed legislation and regulations whether or not Section 102 of NEPA applies.

On August 1, 1973, the Council on Environmental Quality issued guidelines for the preparation of the EIS.[3] The guidelines may be considered a basic outline for the required contents of the EIS. According to CEQ, the following eight items are to be covered in an EIS:

1. A description of the proposed action, including a statement of its purposes and a description of the environment affected;

2. The relationship of the proposed action to land use plans, policies, and controls for the affected area;

3. The probable impact of the proposed action on the environment, including the positive and negative effects, as well as the primary and secondary effects;

4. Alternatives to the proposed action, including, where relevant, those not within the existing authority of the responsible agency;

5. Any probable adverse environmental effects that cannot be avoided;

6. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity;

7. Any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented;

8. Any indication of what other interests and considerations of federal policy are thought to offset the adverse environmental effects of the proposed action identified in items 3 and 5, above.

EPA originally attempted to conduct the EIS review through the use of headquarters personnel. Due to the unexpected volume of statements, EPA decentralized most of this responsibility to its regional offices in 1971. EPA provided guidelines for EIS review in Manual 1640.1,[4] which addresses policies, procedures, and responsibilities for the EIS review, but lacks any definitive technical review procedures for use by the regional offices. To fill this void, the Office of Federal Activities within EPA is preparing detailed guidelines in the form of handbooks for several major project areas. The initial handbook, addressing highway projects, was published in 1973.[5] The document presented here constitutes the technical background for the review of the airport EIS.

In final form, the guidelines are intended to serve as a supplement to EPA Manual 1640.1 and to existing assessment techniques related to secondary impacts and transportation system alternatives. In total, these documents provide the detailed framework for the Environmental Protection Agency review of airport project environmental impact statements. Although these guidelines are concerned mainly with the primary pollutant impacts, the project should include, to the extent possible, consideration of secondary pollutant impacts and primary and secondary nonpollutant impacts. The crux of the review assessment is to ensure that the EIS contains sufficient information to "explore alternative action that will avoid or minimize adverse impacts and to evaluate both the long- and short-range implications of proposed actions to man, his physical and social surroundings, and to nature."[5]

Basically, this document intends to provide technical procedures and guidelines to the regional offices of EPA for the review of the airport EIS. To fulfill that responsibility, the handbook is designed to serve a dual role. First, it provides detailed technical guidance for all aspects of environmental assessment, so as to give the user quick access to pertinent technical discussions and model descriptions and evaluations. Second, it serves as an educational experience for the reviewer for the development of an airport project and the generation of an EIS. In this way, the EPA reviewers can read the handbook initially for a better understanding of the development of an airport project leading to an EIS. Then, while reviewing an individual EIS, the reviewer may refer to the handbook for specific technical information. Finally, the handbook should be incorporated by the Federal Aviation Administration (FAA) into their EIS development process. This would provide FAA and EPA with similar technical capabilities for predicting and assessing environmental impacts. It would also draw the two organizations to a common ground that would eliminate much of the friction during the review of the draft EIS.

The second section of the handbook provides a description of the airport development process. Within the process, the responsibilities of various federal agencies, such as the Department of Transportation (DOT), FAA, and the Civil Aeronautics Board (CAB), are located and explained. Section 3 contains an airport project classification system developed specifically for the handbook. Through the use of basic information describing the airport project, the classification system may be used to predict the probable severity of various pollutants generated by the project. A brief description of the pollutants generated during the construction and operation phases of the project is also provided.

Section 4 presents an assessment of the state-of-the-art techniques for predicting airport-generated impacts. These include air, noise, water and wastewater, solid waste, hazardous materials, ecological and land use impacts. For each pollutant, standards and review guidelines are presented, sources are discussed, assessment techniques are evaluated, and abatement strategies are explained. The fifth section describes the assessment technique for the overall impact of an airport project. This consists of EPA review policies and procedures as set forth in Manual 1640.1. Also included in this section is a description of the various levels of alternatives to an airport project, with an explanation of alternatives available at each level.

2.0 ENVIRONMENTAL REQUIREMENTS WITHIN AIRPORT DEVELOPMENT PROCESS

2.1 DESCRIPTION OF AIRPORT DEVELOPMENT PROCESS

There are four major levels of planning that constitute the airport development process. Familiarity with the airport planning process is essential to the EIS reviewer; it is the only way the reviewer knows at what point in the development of an airport project the environmental impact statement is generated. The reviewer is then aware of the studies which have been completed prior to the statement and of the administrative steps which must be taken before the physical development of the airport can proceed. The highest and most general level is the National Airport System Plan (NASP). The second level is the Airport System Plan, which encompasses an area within NASP. The size of the area included in the Airport System Plan varies; both the State Airport System Plan and the Metropolitan Airport System Plan are included in this level of planning. The next level is the Airport Master Plan, which is developed for a particular airport within the system plan. Finally, the Airport Development Project Plan describes a particular project for an airport within the system plan.

The National Airport System Plan is a plan for the development of public airports in the United States for a period of 10 years. It includes estimates "of the type and estimated cost of airport development considered by the Secretary [of Transportation] to be necessary to provide a system of public airports adequate to anticipate and meet the needs of civil aeronautics..."[6] It should reflect interstate, state, and local airport planning, covering the needs of all segments of civil aviation. It shall also explain the relationships between airports and local transportation systems, forecasted technology developments in the aeronautics field, and the development of other modes of intercity transportation.

Airports within NASP are identified and classified according to the National Airport Classification System.[7] The system classifies airports by enplaned passengers into a primary, secondary, and feeder system, and within each system by aircraft operations into high, medium, and low density. The systems include air carrier airports that are served by scheduled, commercial airlines, and general aviation airports, which serve private and corporate aircraft.

The responsibility for preparing NASP lies with the Secretary of Transportation. The Secretary is also responsible for providing technical assistance to agencies preparing airport system and master plans to ensure that NASP reflects all levels of airport planning. Currently, the Department of Transportation prepares a multimodal transportation needs study every two years. It is likely that NASP will become integrated with this type of study in the future.[8]

The second planning level, the Airport System Plan, determines what airport development is required in a specific area to establish a balanced airport system. The area concerned may be a metropolitan area, a state, a group of states, or parts of states combined. Systems planning includes the general site location, determining preferred sites along with alternative locations. A list of the tasks required for the airport system planning phase may be found in Table 1.

As stated above, the Airport System Plan includes both the State Airport System Plan and the Metropolitan Airport System Plan. The State Airport System Plan defines aviation facilities needed in a particular state to meet the current and future state goals as viewed by the state department of aviation. It includes recommendations for the general location and characteristics of new airports and the expansion of existing ones. The plan shows the timing and estimated costs of the required development. It attempts to relate airport development to both the economic and environmental goals of the state, while at the same time achieving coordination with the state comprehensive planning framework. Finally, it incorporates regional/metropolitan airport system planning to provide a basis for detailed individual airport planning. One of the principal reasons for the State Airport System Plan is that not all state airports are included in the NASP.

The Metropolitan Airport System Plan is a subsystem of the state plan. It is very similar to the State Airport System Plan, except that it deals with a specified aviation or transportation commission. The Federal Aviation Administration provides support documents for both phases of the Airport System Plan.[10,11] The Secretary of Transportation is authorized by the Airport and Airway Department Act of 1970[6] to make system planning grants to the authorized agency engaged in areawide planning. These grants are normally administered by FAA under the Planning Grant Program (PGP).

Table 1. Required Tasks for Airport System Plan[9]

Tasks	Contents
Inventories	Airports; aeronautical activity, analyses and forecasts; airspace; comprehensive, land use and ground transportation plans; socioeconomic factors, analyses, and forecasts; financial resources; public bodies available to finance and implement projects.
	Inventory of environmental information.
Forecasts of aviation demand	Short, intermediate, and long-range forecasts of airport users, operational activity, aircraft mix, and ground transportation data.
Capacity analyses of airfield, terminal area, and access	Relationship of forecast demands to capacity of existing system.
Airspace analysis	Existing and predicted use of airspace, navigation aids, communications, and obstructions.
Determination of airport requirements	Evaluation of existing airports as to suitability, feasibility of expansion, accessibility and role in the system.
	General location of new facilities as to land use, ground transportation, and environmental considerations.
	Means of interconnection between airports in the system.
Alternatives	Analysis of alternative systems and components, including comparison of order of magnitude costs.
Schedules of plan implementation	Staging of development in relation to demand forecasts.
Estimates of development costs	Related to schedule of development.
Financing	Financial actions to implement plan.
Management and operational plan	Organization to implement and operate system; scheduling of operations; pricing schedules.

The Airport Master Plan presents the ultimate development of a particular airport. This applies to the modernization and expansion of an existing airport and the site selection and planning for a new airport. The final site selection for a new airport is made at this stage from the alternatives presented in the Airport System Plan. The requirements of the Airport Master Plan are presented in Table 2. As with the Airport System Plan, the Secretary of Transportation is authorized by the Airport and Airway Development Act of 1970 to make master planning grants to authorized public agencies. The Federal Aviation Administration provides support documents for this phase of the development process as well.[12]

The final step of the airport development process is the Airport Development Project Plan. Airport development covers the construction, improvement, and repair of public airports, including the acquisition of land. The plan consists of what is to be accomplished where, when, and at what cost. Examples of development projects are runways, terminals, navigational aids, roadways, and land acquisition. Certain projects are eligible for federal grants-in-aid under the Airport Development Aid Program. These projects are defined in Part 152 of the Federal Aviation Regulations.

2.2 RESPONSIBILITIES AND REQUIREMENTS OF GOVERNMENT AGENCIES

As discussed in the previous section, the Airport and Airway Development Act of 1970 authorizes the Secretary of Transportation to provide planning grants for system and master planning and grants-in-aid for the actual development. The Secretary of Transportation is also required by the Act to formulate a National Airport System Plan and an aviation advisory commission, and to describe the conditions under which an airport project will be approved. The conditions of the Act further require that consideration will be given to the interests of the communities near the airport and to the environmental effects generated by the airport; opportunity for a public hearing to consider the economic, social, and environmental effects of the project; compliance with all applicable air and water standards; and action to restrict the use of land near the airport to compatible uses.

Table 2. Required Tasks for Airport Master Plan

Tasks	Contents
Airport Requirements	
– Inventory	Existing airport facilities, airspace structure and navaids, related land use, existing airport plans, comprehensive plans, laws and ordinances, financial resources, socioeconomic data, and ground transportation data.
	Inventory of environmental studies.
– Forecasts of aviation demand	Short, intermediate, and long-range forecasts of air traffic, based aircraft, aircraft mix, aircraft operations, enplaned passengers, air cargo, and airport access.
– Demand/capacity analysis	Airfield, terminal buildings, and airport access.
– Facility requirement determination	Runways, gates, aprons, terminal and cargo buildings, parking, access, and overall land area.
– Environmental study	Studies of noise, hydrology, water quality, air quality, conservation, community impact, impact on recreation areas, parks, and historic sites.
Site Selection	Evaluation of possible sites, including existing airports; public discussion; criteria for evaluation of alternatives should include airspace requirements, environmental factors, community growth, airport access, availability of utilities, land costs, and engineering costs.
Airport Plans	
– Airport layout plan	Configuration of runways, taxiways, aprons, terminal areas, air navigation facilities, and runway approach zones.

Table 2. Required Tasks for Airport Master Plan (Contd.)

Tasks	Contents
– Land use plan	Areas on the airport (terminal complex, maintenance facilities, industrial sites, internal roadways, buffer zones, recreation sites, etc.); areas outside the airport boundary (areas affected by obstruction clearance criteria and noise impacts), location of navigation aids.
– Terminal area plans	Concept studies, to be followed by large-scale plans of terminal and cargo building areas, hangars, motels, commercial and service areas, airport entrance and service areas, etc.
– Airport access plans	Airport access to central business district or highway connections; and mass transportation.
Financial Plan	
– Schedule of proposed development	Staging of development.
– Estimates of development costs	Balance between costs for administration, operation, maintenance and income.
– Economic feasibility	Estimates of costs vs. revenues.
– Financing	Sources of financing.
Operational Plan	Pricing policy, including landing fees, parking charges, space rentals, etc.; scheduling, such as traffic segregation or prohibitions, hours of operation; and flight paths.

2.2.1 Federal Responsibilities

By February of 1971, the Federal Aviation Administration, under the direction of the Secretary of Transportation, began issuing planning grants. FAA had also by this time developed advisory circulars for the development of the State Airport System Plan,[10] the Metropolitan Airport System Plan,[11] and the Airport Master Plan.[12] The Planning Grant Program Handbook, revised by FAA in June, 1974 provides a complete description of the requirements at each stage of the airport development process.[13]

The responsibilities of the Federal Aviation Administration include the development of the National Airport System Plan and the provision of technical guidance to agencies engaged in airport planning. FAA is also responsible for such things as airspace clearance, the installation of airport traffic control towers and navigational aids, and all aspects of aircraft and airport safety. Finally, FAA has the authority to provide grants-in-aid under the Airport Development Aid Program and the Planning Grant Program. Overall, the Federal Aviation Administration may best be described as the "technical arm" of the planning process.

The Civil Aeronautics Board is an independent regulatory agency that also has input into the airport development process. The Board may be considered the "economic arm" of the planning process, since it determines routes and fares. CAB works with FAA on safety issues affecting its policies. For instance, if FAA determines that airspace limitations will only allow a certain number of flights into a particular airport, CAB must restrict its schedules and routes to meet the safety requirements.

As discussed above, the airport development process includes input from the Secretary of the Department of Transportation, the Federal Aviation Administration, and the Civil Aeronautics Board. All of these agencies play major roles in the planning process as described by various acts and orders. One of the products of the planning process, which is given major emphasis in this handbook, is the environmental impact statement (EIS). The introduction of the handbook provides the background on the requirements for an EIS.

As previously stated, the National Environmental Policy Act requires the preparation of an environmental impact statement for each major federal action significantly affecting the quality of the human environment. According to the procedures set forth by the Department of Transportation for considering environmental impacts,[14] the final environmental impact statement for any airport development grant may be approved by the FAA administrator or his designee. For any project in the following areas, that approval may be given only after concurrence by the Assistant Secretary for Environment, Safety, and Consumer Affairs (TES), who is located within the Office of the Secretary of Transportation:

1. Any new airport serving a metropolitan area.

2. Any new airport or runway extension for an airport located in whole or in part within a metropolitan area and either certified under Section 612 of the Federal Aviation Act of 1958 or used by large aircraft of commercial operators.

3. Any project to which a federal, state, or local governmental agency has expressed opposition on environmental grounds.

4. Any project for which TES requests an opportunity to review and concur in the final statement.

5. Any project for which the FAA administrator requests review and concurrence by TES in the final statement.

Within the same set of procedures, DOT generally defines major federal actions that require environmental impact statements:[15]

1. Any effect that is not minimal on properties protected under section 4(f) of the DOT Act or section 106 of the Historic Preservation Act.

2. Any action that is likely to be highly controversial on environmental grounds.

3. Any action that is likely to have a significantly adverse impact on natural, ecological, cultural, or scenic resources of national, State, or local significance.

4. Any action that is likely to be highly controversial with respect to the availability of adequate relocation housing.

5. Any action which (a) causes a significant division or disruption of an established community or disrupts orderly, planned development or is determined to be significantly inconsistent with plans or goals that have been adopted by the community in which the project is located; or (b) causes a significant increase in congestion.

6. Any action which (a) is determined to be inconsistent with any Federal, State, or local law or administrative determination relating to the environment; (b) has a significant detrimental impact on air or water quality or on ambient noise levels for adjoining areas; or (c) may contaminate a public water supply system.

7. Other action that directly or indirectly significantly affects human beings by creating an adverse impact on the environment.

The Federal Aviation Administration has further specified the kinds of airport projects which require an environmental impact statement or a negative declaration in its recently revised Order, "Instructions for Processing Airport Development Actions Affecting the Environment."[16]

The administrator of FAA makes the final decision of whether a particular Airport Development Project Plan requires an EIS. To date, both FAA and DOT have filed environmental impact statements for various development projects. A limited number of environmental impact statements have been prepared for Airport Master Plans, such as the EIS for Cedar Rapids Municipal Airport in Iowa.[17] The EIS prepared for the Illinois State Airport System Plan[18] represents one of the few completed for Airport System Plans. Many of the State System Plans and Master Plans lack environmental impact statements. This is due in part to the fact that many of these plans are still in a state of development. An EIS has not been prepared for the National Airport System Plan (NASP), although airports that will be eligible for federal funding are selected at this point. On all levels of planning, and especially at the higher levels, progress must be made on including the EIS in the planning process.

The Civil Aeronautics Board has filed only one EIS to date,[19] although many of its actions require an EIS according to NEPA. At the present time, the Council on Environmental Quality (CEQ) is urging CAB to include EIS preparation in their decisions. The Civil Aeronautics Board has published a notice of proposed rulemaking for EIS guidelines.[20] The regulation will include the identification of major federal actions significantly affecting the environment as determined by CAB.

On the federal level, serious EIS consideration is given only to airport development plans. EIS preparation for system and master plans is relatively scarce. The decision of the EIS requirement for NASP has been left to the courts. Therefore, at least in the near future, the handbook will have its main application on environmental impact statements prepared for Airport Development Project Plans.

2.2.2 State and Local Responsibilities

The National Environmental Policy Act requires any federally funded project that significantly affects the human environment to be accompanied by an EIS. Theoretically, this includes all levels of project planning and development by DOT and FAA, and all regulations developed by CAB. But what of the projects funded with monies from other than federal sources? To fill this void, some state and local governments have instituted their own forms of NEPA. Examples of state and local environmental impact reporting requirements are included so that the reviewer is familiar with related demands being met by the EIS.

Fifteen states and Puerto Rico have adopted requirements for environmental impact statements as of October, 1973. Implementation of most of the programs has been slow, however, and with the exception of California, their net effect appears to be rather small.[21] The effectiveness of many of the programs is severely limited because the EIS requirements do not extend to private activities or actions of local governments. Also, adequate enforcement of the requirements is usually not provided by the programs. This leads to low quality statements, and in some cases, no statements at all.

California was the first state to establish a NEPA-type EIS requirement. The California Environmental Quality Act of 1970[22] applies to local and state actions, as well as to private projects that require state or local governmental permission. In upholding California's Act, the California Supreme Court ruled in 1972 that an environmental impact report (EIR) must be prepared before a governmental entity approves a private project that is subject to public permission and that could have a significant effect on the environment. The Act requires the Secretary of the State Resources Agency, in consultation with the Office of Planning and Research, to issue guidelines for the implementation of the EIR requirement. Furthermore, local governments were required to adopt similar guidelines and procedures by April 6, 1973. It should be noted that an environmental impact report cannot be substituted for an environmental impact statement used to satisfy the NEPA requirements, unless FAA has been involved in the project since the inception of the EIR.

On December 18, 1972, the City of Palo Alto, California adopted Environmental Impact Assessment (EIA) procedures.[23] The procedures set forth a list of categorical exemptions for certain projects that do not require an environmental impact report. If the project is exempt, only a preliminary environmental assessment report (a one-page form) is required and the project is then handled through normal channels. If the project is not exempt, an Environmental Impact Assessment report is prepared and submitted to the Planning Department. If the impact of the project is not deemed to be significant, the Planning Department signs the Negative Declaration on the Environmental Impact Assessment report. A Negative Declaration is a short report issued in lieu of an EIA that states the project under consideration will not have a significant effect on the human environment. If the impact of the project is determined to be significant, a full environmental impact report must be made. The report is prepared by the Planning Department and, once completed, is presented at a public hearing. The project may be denied on the basis of the EIA after the public hearing. A copy of the report and the Notice of Completion is then sent to the State Department of Resources. The EIA prepared by the local planning department may be used as the state EIR when the project requires approval by both the state and local agencies.

Although very few states and an even smaller percentage of local governments have EIS requirements, state and local regulations have been shown to have the potential for becoming effective and viable control mechanisms. Since the federal acts can control only projects supported by federal funds, legislation is required on state and local levels to control the remaining government-financed projects and also privately-financed projects. Appendix A contains a list of existing state environmental impact statement requirements, along with the names and addresses of the responsible individuals. This information is useful not only for state EIS requirements, but also for state standards and criteria related to pollutants and impacts.

3.0 CLASSIFICATION SYSTEM FOR PROBABLE ENVIRONMENTAL IMPACTS OF AIRPORT PROJECTS

3.1 TYPES OF AIRPORT PROJECTS

An airport project encompasses all types of improvements, from fencing of airport property to the construction of a new airport. As defined in a previous section, FAA has determined which types of projects require an EIS. If a project does not fall into any of the categories listed in Section 2.2.1, a Negative Declaration is accepted. The California Environmental Quality Act of 1970 takes this action a step further and defines specific projects as categorical exemptions, and therefore not requiring an EIS. For the purpose of constructing the handbook to be as widely applicable as possible, all airport projects will be considered, including ones that do not currently require an EIS.

Airport projects may be divided into eight general categories:

1. Construction of a new airport.
2. Construction or extension of a runway, including the turnarounds, taxiways, and aprons.
3. Construction, enlargement, or improvement of the terminal building and also storage and service, hangar, cargo, crash/fire/rescue, and office areas in other associated buildings.
4. Installation and modernization of navigational equipment and lighting. This involves visual approach lighting systems, runway lighting, rotating and obstruction beacons, and other types of lighting systems, plus such forms of navigational equipment as instrument approach landing systems, control towers, and segmented circles.
5. Construction or improvement of access roads and parking lots, and forms of mass transportation. Included here are the relocation of roads taken during land acquisition, curb parking around terminal buildings, and parking lots for employees and rent-a-car agencies. The development of rail mass transit and initiation of bus systems are also members of this category.
6. All forms of land acquisition. This may be required for the expansion of the airport itself or for a clear zone for obstructions or noise.

7. Construction or improvement of utilities. This encompasses sewers, gas and electrical lines, and communication hardware.

8. Seeding, grading, and fencing. This may be performed in connection with other projects or by itself.

3.2 SUMMARY OF IMPACTS

Each of the eight categories of airport projects defined above generates certain types and amounts of pollutants. One of the primary rationales for establishing this particular system of categories is to group projects according to their pollutant characteristics. A more detailed discussion of pollutants may be found in Section 4.0. In general, the long-term operational impacts are the most difficult to deal with because they are not easily mitigated. Construction impacts, which are short term, can be equally serious but are often easier to counter or eliminate entirely.

3.2.1 Construction Phase

During the construction phase, certain types and sources of pollutants may be expected. Basically, the pollutants emitted by construction equipment are the same regardless of what type of construction project is undertaken. Although the magnitude will most certainly vary, the sources and types will be fairly constant. Of crucial concern in the construction phase are solid waste management, sedimentation and erosion, and air pollution.

The construction phase of a project can be expected to generate the full range of pollutants. Many types of construction vehicle and equipment will emit air pollution in the form of hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_X), sulfur dioxide (SO_2), and particulates. Another type of air pollution is dust created by excavation and the movement of equipment and materials. The magnitude of emission of these pollutants is dependent on the size of the project.

Noise is generated by various types of heavy equipment, being dependent on the individual piece of equipment. Water pollution is created through sedimentation and erosion caused by vehicles traveling through wet areas and waterways, and rain flowing across bare land. Solid wastes generated by construction consist of waste materials and debris. As with air pollution, the magnitude of most construction pollutants is based upon the size and type of project.

3.2.2 Operation Phase

Once the construction phase is completed, the operation phase begins. Of primary concern during the operation of any airport is the land use impact. The impact on land use in the environs of the airport reflects all of the impacts on each environmental subsystem. One major component is the noise impact, which is serious for any size airport. The effect on air quality is potentially serious at busy commercial airports (using FAA's Airport Classification System) and in areas where non-degradation of air quality is a concern. The primary sources of air pollution include aircraft operations and access traffic. Wastewater management must be dealt with at all airports, especially with respect to the quality of runoff water and the treatment of industrial waste streams. Large airports draw a significant amount of potable water, equivalent to a medium-sized city, and must locate an adequate supply of water. The disposal of the solid waste generated by in-flight food services, airport restaurants, and other activities can have serious impact, depending on the size and location of the airport.

Besides airport size, expressed as million annual passengers (enplaning and deplaning), another significant factor in the determination of an airport's long-range impact is the presence of a maintenance base. These bases are generally found at terminal airports, located on the coasts in mild climate zones, although minor maintenance is done at nearly all airports. The characteristics of their wastewater and solid waste streams are like those of certain industries, in contrast to the domestic characteristics of the other airport waste streams. It is difficult to obtain information on the size of most maintenance bases, in terms of the number of employees, because the airlines consider this proprietary information.

The impact on ecosystems on and near the airport must also be considered. The environmental impact statement should show evidence of an awareness of the variety of species in the area, as well as the sensitivity of those species to the changes caused by the airport project.

Obviously, there are many more sources of pollutants during the operational phase than those listed above. In Section 4.0, pollutants generated at both phases of an airport project will be described in detail by source, magnitude and abatement strategy.

3.3 RANKING SYSTEM

The ranking system has been devised basically as an operational index for the handbook. When a reviewer is assessing an EIS for a particular airport project, the ranking system is used to predict the magnitudes of the seven basic impacts as described in the handbook. The impacts that are included are air, noise, water and wastewater, solid waste, land use, hazardous materials, and ecology. When the magnitude of each impact is estimated, the reviewer is referred to a portion of Section 4.0 for a detailed discussion of the given impact.

As stated in the previous section, the airport projects have been grouped into eight categories according to expected impacts. Therefore, the ranking system considers each of the eight categories. The ranking system provides a letter rating (A, B, or C) for each pollutant relative to each category. The eight basic categories are described as follows:

1) New airport

   - If the main runway is greater than or equal to 4000 ft* in length, classify project as New Airport I.
   - If the main runway is less than 4000 ft, but the project is adjacent to one of the following land uses, classify project as New Airport I:
     - 4(F) land and properties listed on the National Register of Historic Places;[24]
     - Residential land;
     - Institutional land (such as schools, hospitals, etc.);
     - Certain types of sensitive commercial land (such as retail stores).

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*Study of the runway characteristics for standard conditions of typical piston and jet aircraft reveals that a breakoff point between the runway length requirements for piston aircraft and jet aircraft is 4000 ft.

- If the main runway is less than 4000 ft and the project is not adjacent to one of the land uses listed above, classify project as New Airport II.

2-a. New or extended runway, with any of the additional improvements listed under 3 through 8 below:

- If the new or extended runway is greater than or equal to 4000 ft, or adjacent to any of the above listed land uses, classify project as New or Extended Runway I (with other improvements).

- If the new or extended runway is less than 4000 ft and not adjacent to any of the land uses listed above, classify project as New or Extended Runway II (with other improvements).

2-b. New or extended runway, with no other improvements, except the installation or modernization of runway lighting or navigational equipment (4):

- If the new or extended runway is greater than or equal to 4000 ft, or adjacent to any of the land uses listed above, classify project as New or Extended Runway I (with no other improvements).

- If the new or extended runway is less than 4000 ft, and not adjacent to any of the above listed land uses, classify project as New or Extended Runway II (with no other improvements).

3. Construction, enlargement, or improvement of terminal buildings and other related airport buildings, to include:

- Lobby, ticketing, and baggage areas;

- Concourse, concession, and public areas;

- Gate, storage, and service areas;

- Hangar and cargo areas;

- Crash/fire/rescue building;

- Office areas.

4. Installation or modernization of lighting or navigational equipment, including:

- Various approach lighting systems, such as Visual Approach Slope Indicator (VASI);

- Runway lighting system;

– Rotating and obstruction beacons;

– Instrument approach landing system;

– Control tower;

– Wind cone and segmented circle.

5. Construction or improvement of access roads and parking lots, and forms of mass transportation, including:

– Relocation of roads displaced during land acquisition;

– Curb parking near terminal area;

– Parking lots for employees, visitors, passengers, and rent-a-car agencies;

– Bus and fixed guideway mass transit systems.

6. Land acquisition for:

– New airport;

– Runway extension;

– Clear zones;

– Other airport improvements.

7. Construction or improvement of utilities, including:

– Storm and sanitary sewers;

– Electric, gas, and telephone lines.

8. Fencing, grading, and seeding.

Once the reviewer has established which category a particular project belongs in, Table 3 is used to rank each of the pollutants generated by the project. The ranking indicates whether an analysis of the impact of the pollutants is normally required for that airport project category.

The impact ratings determined from Table 3 are for the operational phase of the airport project, and do not include the construction phase. As pointed out before, the construction impacts are similar for various projects. In Section 4.0 both the construction and operational impacts are discussed for each pollutant. Once the reviewers complete the initial reading and studying of the handbook and incorporate it into the review process of

Table 3. Environmental Impact Rating by Project Type and Pollutant

Project Type	Air	Noise	Water & Waste-water	Solid Waste	Land Use	Hazardous Materials	Ecology
1) New Airport I	A	A	A	A	A	A	A
2) New Airport II	B	B	B	B	C	C	B
3) New or Extended Runway I (with other improvements)	A	A	A	A	A	A	A
4) New or Extended Runway II (with other improvements)	B	B	A	B	C	C	B
5) New or Extended Runway I (with no other improvements)	A	A	A	B	B	B	B
6) New or Extended Runway II[1] (with no other improvements)	B	B	A	C	C	C	C
7) Terminal and Other Related Airport Buildings[2]	B	B	A	A	C	B	C
8) Lighting and Navigational Equipment[2]	B	B	C	C	C	C	C
9) Ground Transportation and Related Parking[2]	B	B	B	C	B	C	B
10) Land Acquisition[2]	C	C	C	C	A	C	B
11) Utilities[2]	C	C	B	C	C	C	C
12) Fencing, Grading, and Seeding[2]	C	C	B	C	C	C	B

[1]Most projects dealing with the paving of a turf runway are included in this category.

[2]If a combination of project types 7 through 12 is included in an EIS, the worst rating for each of the pollutants is used.

RATING SCHEME:

A Serious Impact: Refer to discussion of pollutant in Section 4.0 concerning predictive models, abatement methods, and standards and criteria.

B Possible Impact: Seriousness of the impact is left to the discretion of the reviewer; dependent upon details of the project and the environment adjacent to the project.

C Insignificant Impact: Normally this impact would not need to be considered; EIS reviewer should be aware of possible exceptions.

a few environmental impact statements, they will have a good understanding of construction impacts. Normally speaking, the severity of the construction impacts for each pollutant is similar to the severity of the operational impacts, given a particular project type. The construction impacts are normally much simpler and more straightforward than the operational impacts. Therefore, once the construction impacts and abatement strategies are understood, the reviewer should know what to expect concerning emissions and controls for a given project.

After the ratings for each pollutant generated by a given product have been determined, Table 4 is used to refer the reviewer to the applicable discussion in Section 4.0. Once again, the reviewer must make certain decisions while using Table 3 to rank the pollutants generated by a project. A rating of B and C may be significant for certain projects and not for others. After becoming accustomed to the handbook and reviewing a number of airport EIS, the reviewer will find that decisions for most projects will be relatively straightforward. If there is any doubt, the reviewer should refer to the appropriate discussion for a particular pollutant. Given that the impact is significant for certain pollutants, Table 4 may be incorporated as an index for the efficient use of the remainder of this document.

Table 4. Location of Information by Pollutant

Pollutant	Section	Page
Air	4.1	35
Noise	4.2	54
Water & Wastewater	4.3	73
Ecology	4.3	73
Solid Waste	4.4	92
Land Use	4.5	98
Hazardous Material	4.6	107

4.0 STATE-OF-THE-ART ASSESSMENT TECHNIQUES FOR AIRPORT-GENERATED IMPACTS

4.1 AIR IMPACT

4.1.1 Federal, State, and Local Standards

The administrator of the Environmental Protection Agency was required by the Clean Air Amendments of 1970 to establish national ambient air quality standards. Ambient air was defined by EPA to mean "that portion of the atmosphere, external to buildings, to which the general public has access."[25] The National Ambient Air Quality Standards developed by EPA are presented in Table 5.

The standards are written to address two related but separate effects, thereby resulting in both primary and secondary standards. The primary standards were developed to protect against adverse health effects, while the secondary standards were designed to protect against adverse welfare effects, such as animal, plant, and material damage.

In addition to the National Ambient Air Quality Standards (NAAQS), EPA has prescribed a regulation for the control and/or prohibition of fuels and additives for use in motor vehicles or motor vehicle engines.[27] The regulation deals mainly with lead and phosphorus additives in motor vehicle gasoline. The regulation was based upon a determination by the administrator of EPA that the emission product of the fuel or additive will endanger the public health or welfare, or will impair to a significant degree the performance of a motor vehicle emission control device in general use.

To further control the emissions of aircraft, EPA promulgated emission standards and test procedures for aircraft.[28] The administrator of EPA was directed by the Clean Air Amendments of 1970 to establish standards applicable to the emission of any pollutant for any class of aircraft, which in his judgment may cause or contribute to air pollution that endangers the public health or welfare. The regulation includes fuel-venting emission standards for new and in-use aircraft gas turbine engines; exhaust emission standards for new and in-use aircraft gas turbine engines, aircraft piston engines, and on-board auxiliary power units, and test procedures applicable to aircraft gas turbine engines and aircraft piston engines.

Table 5. National Ambient Air Quality Standards[26]

Pollutant	Primary Standard: Annual Mean	Primary Standard: Max. Concentration Not To Be Exceeded More Than Once Per Year		Secondary Standard: Annual Mean	Secondary Standard: Max. Concentration Not To Be Exceeded More Than Once Per Year	
Sulfur Dioxide (SO_2)	80 (μg/m^3) .03 (ppm) (arithmetic)	365 (μg/m^3) .14 (ppm)	24-hr.	60 (μg/m^3) .02 (ppm) (arithmetic)	260 (μg/m^3) .10 (ppm) 1300 (μg/m^3) .5 (ppm)	24-hr. 3-hr.
Particulate Matter	75 (μg/m^3) (geometric	260 (μg/m^3)	24-hr.	60 (μg/m^3) (geometric)	150 (μg/m^3)	24-hr.
Carbon Monoxide		10 (mg/m^3) 9.0 (ppm) 40 (mg/m^3) 35.0 (ppm)	8-hr. 1-hr.		Same as Primary	
Photochemical Oxidants		160 (μg/m^3) .08 (ppm)	1-hr.		Same as Primary	
Hydrocarbons		160 (μg/m^3) .24 (ppm)	3-hr. (6-9 AM)		Same as Primary	
Nitrogen Dioxide (NO_2)	100 (μg/m^3) .05 (ppm) (arithmetic)			Same as Primary		

Section 110 of the Clean Air Amendments of 1970 required the states to submit plans providing for implementation, maintenance, and enforcement of the National Ambient Air Quality Standards to the administrator of EPA. The State Implementation Plans (SIP) that are submitted to satisfy this requirement should consist of three basic components. First, there are non-degradation standards that state the amount particular sources of air pollutants may increase the levels of pollutants, even if the standards are not exceeded. Next, the indirect source regulation deals with sources (such as stadiums, shopping centers, airports, etc.) that generate high volumes of traffic and congestion. Finally, the air quality maintenance areas (AQMA) defined in the SIPs are designated areas that are expected to exceed the standards in the next ten years. Along with the designated areas are plans for maintaining the levels of air pollution in these areas within the limits of the defined standards. To achieve the standards for CO and photochemical oxidants, detailed transportation control plans were required in 18 of these plans.

Within this framework, the reviewer must determine whether the project is consistent with the applicable SIP (or SIPs if an interstate project) or, in the absence of transportation-related controls, whether the project-induced emission pattern changes will interfere with attainment or maintenance of the National Ambient Air Quality Standards. Recently published regulations discuss the U.S. EPA procedures for review of indirect sources.[29] Airports are specifically mentioned as an indirect source of air pollution; however, the specific guidelines pertaining to review of airports have not yet been published. In areas where parking management regulations are in effect, review of facilities is performed under such regulations, rather than under the indirect source regulations. Lists of the areas having parking management regulations and the procedures for review are found in the Federal Register.[30]

4.1.2 <u>Identification of Sources and Discussion of Pollutant Dispersion</u>

The construction required for an airport project may generate substantial quantities of air pollution. The contaminants consist of dust, chemicals, smoke, and exhaust emissions, including carbon monoxide (CO), nitrogen oxides (NO_x), hydrocarbons (HC), sulfur dioxide (SO_2), and particulates. The following types of construction activities should be considered when attempting to control air pollution:

1. Clearing, grubbing, and stripping;
2. Excavation, blasting, sandblasting, and grinding;
3. Quarry drilling and rock crushing;
4. Cement and aggregate hauling;
5. Use of haul roads.

Other contributors to the air pollution problem include:

1. Volatiles escaping from asphalt and cutback materials;
2. Refuse burning;
3. Emissions from concrete batch plants;
4. Smoke from asphalt plants;
5. Use of herbicides and fertilizers;
6. Exhaust emissions from all types of construction equipment.

The air pollution generated during the operational phase of an airport project originates from seven basic sources. One of the major sources is aircraft engine exhausts. The major pollutants contained in the engine exhaust are CO, HC, NO_x, and particulates. The amount of these pollutants emitted by a particular airport is based upon the number of operations and the types of aircraft used at the airport. Also, the elevation, temperature, and wind speed and direction affect the levels of pollutants.

The second source, which is also a major contributor to the total air pollution problem, consists of emissions from the operation of gasoline-fueled ground service equipment. The pollutants generated by these vehicles include CO, NO_x, HC, SO_2, and particulates. Heavy- and light-duty trucks, tractors, sweepers, power generators, and fuel trucks are examples of the vehicles that make up this source. The total pollutants emitted from this source are dependent on the numbers and types of vehicles used. This, in turn, is based upon the numbers and types of aircraft being serviced and the airline owning the service vehicles.

Access traffic entering and leaving the airport constitutes the third source. The pollutants emitted by this source are similar to those emitted by the gasoline-fueled ground service equipment. The contaminants generated by these vehicles are based upon the numbers and types of vehicles, the distance traveled within and immediately adjacent to the airport site, the contaminants emitted per gallon of fuel, and the average mileage per gallon of fuel. In many instances, this source can be the second largest contributor to total air emissions, next to aircraft engine exhaust. At Los Angeles International Airport, the vehicles entering and leaving the airport emitted 25% of the total pollutants emitted by all sources within the airport boundary in 1970.[31]

The fourth source includes engine exhaust emissions during maintenance. Normally, the gas turbine engines are run at idle and cruise speeds during testing and maintenance. Given the modes of operation, along with the numbers and types of engines tested, emissions may be calculated. Most maintenance facilities are located at airports that serve originating and terminating flights, such as the San Francisco International Airport. Therefore, the importance of this source is dependent on the location of the airport and the number of maintenance facilities at the given airport.

Heating and air conditioning plants compose the fifth source of air pollutants. Depending on what type of fuel is used, the pollutants generated by this source may include CO, HC, NO_x, SO_2, particulates, and aldehydes. The significance of this source on the total air pollution generated by the airport is based upon the size of the terminal buildings and hangar requirements for service and maintenance.

The sixth source of air pollution is fuel handling and storage system. This source is responsible for significant emissions of HC. An underground fuel distribution system reduces the possibility of accidental spillage and is also more efficient. The type of tank used for storage determines the amount of evaporative loss, along with the type of fuel being stored.

The final source encompasses a number of miscellaneous air pollutant emitters. Such things as boilers, chrome plating tanks, paint bake ovens and spray baths, and degreasers are all sources, their significance being dependent on their size and use. Overall, the amount of pollution generated by these sources is small.

Given the various sources of air pollution, the total emissions for an airport may be calculated. While determining the emissions generated by each source, one should keep certain facts in mind. First, both aircraft and automobile emissions are controlled by federal law. The law is being implemented on a stepwise basis. That is, each year the emission requirements become more stringent, until the final emission level is achieved. Therefore, the emissions generated by a particular group of aircraft or automobiles are dependent on not only the number and type, but also the age distribution and the regulations corresponding to the forecast date. Although there are no current laws regulating emissions from ground service equipment, this same reasoning must be considered if regulations are implemented in the future. Also, regulations dealing with fuel type requirements will have an impact on emissions generated by the heating and air conditioning plants. This is especially true today when a limited quantity of fuel exists.

Once the emission sources are located and the rates of emission calculated, the concentration levels of the regulated pollutants may be determined. The concentration levels are based upon emission rates, meteorological factors and topographical features. One of the important meteorological factors is the height of the mixing layer. This layer includes the total volume of air that is available for the dilution of air pollutants. When the temperature decreases more rapidly than 5.4°F for each 1000 ft of elevation, the atmosphere is considered unstable. Under this condition, the height of the mixing layer is high, and mixing is facilitated. When the temperature decreases less rapidly, the atmosphere is stable and the mixing of pollutants is inhibited due to a lower mixing height. During a temperature inversion, very little mixing takes place above the base of the inversion, thereby containing the pollutants to levels near the ground. In summary, the lower the mixing layer, the smaller the volume of air available for the dilution of pollutants, and therefore the higher the concentration of pollutants. Given the mixing layer and the horizontal wind speed, the ventilation rate may be determined. This rate will determine the concentration of pollutants, given emission rates and locations.

Topographical features affect the concentration of pollutants through their effect on the air flow patterns above the area under consideration. Surface roughness and surface temperature differences create turbulence and thermal mixing that can affect the dispersion of the pollutants. Examples of such features include the channelization of air flow through valleys, the persistence and intensification of inversions in valleys, and the air circulation between land and water areas.[32]

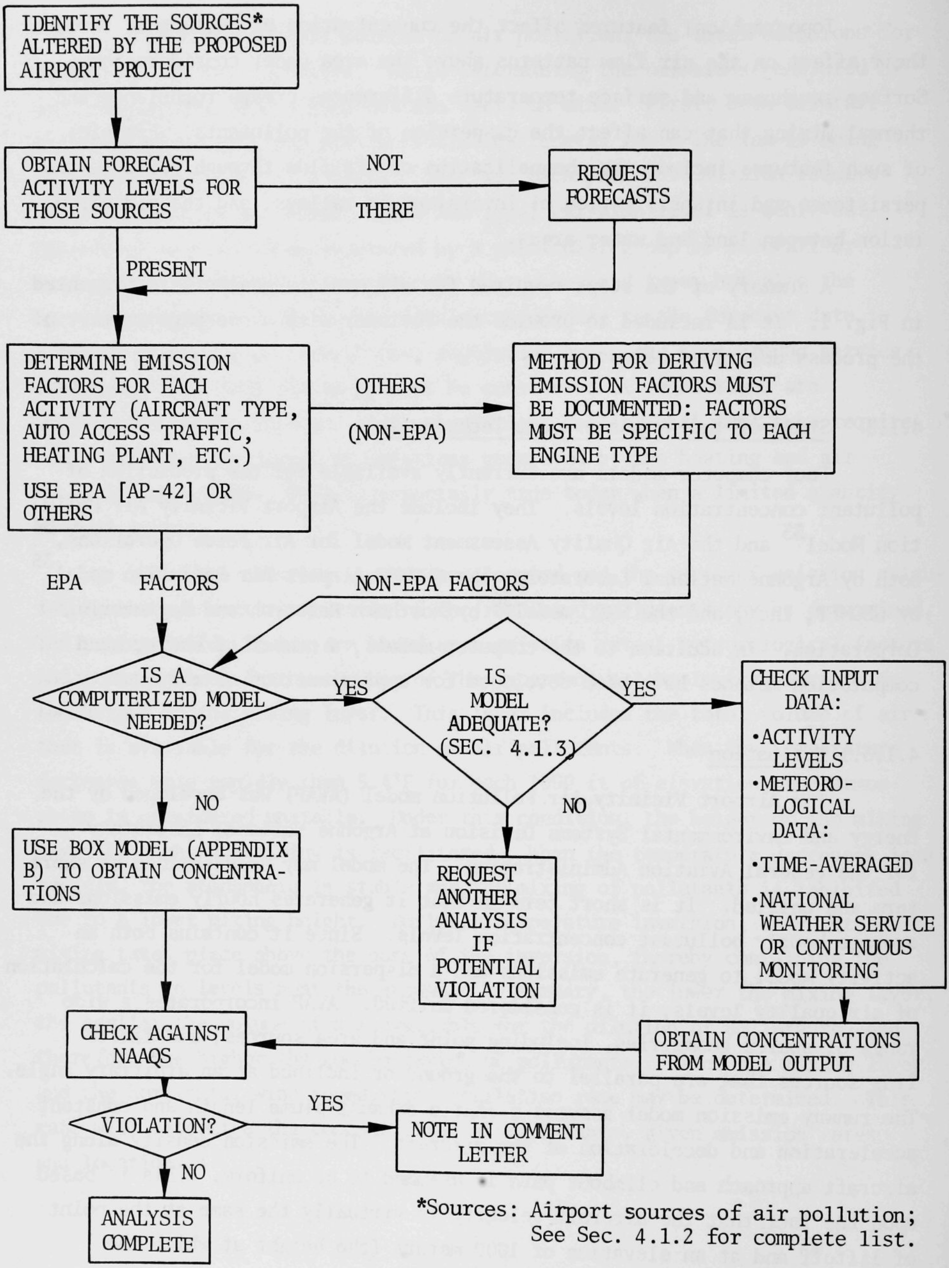
A summary of the steps required for air quality analysis is presented in Fig. 1. It is included to provide the reviewer with a one-page summary of the process described below.

4.1.3 State-of-the-Art Assessment Techniques

Four computer models are currently available for the prediction of pollutant concentration levels. They include the Airport Vicinity Air Pollution Model[33] and the Air Quality Assessment Model for Air Force Operations,[34] both by Argonne National Laboratory, the GEOMET Airport Air Pollution model[35] by GEOMET, Inc., and the NREC model[36] by Northern Research and Engineering Corporation. In addition to the computer models, a number of short, hand computation methods have been developed for approximations of air quality.

4.1.3.1 Evaluation

The Airport Vicinity Air Pollution model (AVAP) was developed by the Energy and Environmental Systems Division at Argonne National Laboratory for the Federal Aviation Administration. The model may be described as short term and unified. It is short term in that it generates hourly emissions and average hourly pollutant concentration levels. Since it contains both an activity model to generate emissions and a dispersion model for the calculation of air quality levels, it is considered unified. AVAP incorporates a wide range of source geometries, including point and area sources, and finite line sources that are parallel to the ground or inclined at an arbitrary angle. The runway emission model assumes a finite exhaust plume length and constant acceleration and deceleration of the aircraft. The emission density along the aircraft approach and climbout path is assumed to be uniform. This is based upon the fact that the aircraft velocity is virtually the same at the point of liftoff and at an elevation of 1000 meters (the height at which the



*Sources: Airport sources of air pollution; See Sec. 4.1.2 for complete list.

Fig. 1. Steps For Air Quality Analysis For Airports

emissions of the aircraft no longer have a significant effect on ground level concentrations). The runway landing and takeoff aircraft distributions are formulated on the simplified assumption that the runway usage patterns can be classified according to two general opposite wind directions. The model is currently being generalized for runway and taxiway use classifications to four wind quadrants.

Data acquisition for the development of the model took place at O'Hare International Airport and Orange County Airport. Data for the evaluation of AVAP was collected at Washington National Airport.[37] When AVAP and the NREC models were compared to empirical data collected at Washington National, two major results were found.[38] First, AVAP tended to underpredict in most cases. Second, AVAP showed a marked improvement over the predictive capabilities of the Northern Research and Engineering Corporation (NREC) model. One reason for the underpredictive performance of AVAP was an inaccurate and incomplete environ emission inventory. The differences between the results of the two models were due in part to the different aircraft activity descriptors, aircraft engine emission factors, vehicle roadway activity models and emission factors used by the models, and also the limitation of the NREC model to a point-source dispersion display.

Statistical tests indicate that the distributions of modeled concentrations and logarithms of concentrations differ from the observed distributions possibly because of background concentration levels and fluctuations in airport activities that are not accounted for in the model.[39] The best correlations between calculated and observed hourly and 24-hr average CO concentrations were obtained for weekdays at Washington National Airport during the test period for which detailed airport and roadway activity data were available. The test period consisted of two 10-day sessions. Because of certain operational problems, only three sites were included when the correlations were derived. Correlation coefficients were as high as 0.77 for the 24-hr average level and 0.64 for the hourly level.

The Air Quality Assessment Model for Air Force Operations was also developed by the Energy and Environmental Systems Division at Argonne National Laboratory, sponsored by the U.S. Air Force. The model is composed of four computer programs. The first is the meteorological data program, which processes historical weather data and generates climatology records. Next is the source inventory program that generates the source emission inventory. The third program consists of emission and dispersion subroutines. This program generates concentrations for up to nine pollutants and computes time period average concentrations on a monthly or annual basis, using the corresponding emission and climatological data. The short-term dispersion model constitutes the final program. This program is identical to the third one, except it computes hourly average pollutant concentrations using hourly average meteorological and emission data. The dispersion computation routine incorporated by this model is the same used in the AVAP model.

The Air Quality Assessment Model for Air Force Operations generates both short- and long-term concentration levels, while AVAP generates only hourly (short-term) concentration levels. The general framework of the long-term model resembles the original Air Quality Display Model (AQDM) by TRW Systems.[40] The main modifications that have been made to improve AQDM are the:

1. Use of six stability categories to compute verticle dispersion coefficients;

2. Changes in the computation of the plume rise;

3. Incorporation of downwash rules by Briggs;

4. Addition of a wind profile law;

5. Addition of a line-source model;

6. Modification of the mixing depth algorithm;

7. Generalization of the climatological-dispersion approach to allow for monthly as well as time-of-day computations of air quality;

8. Expansion to allow for up to nine pollutant species.

Currently, the developers are in the process of testing and validating the model.

The GEOMET Airport Air Pollution Model was developed by GEOMET, Inc., under the sponsorship of the U.S. Environmental Protection Agency. Basically, GEOMET is a revision of the Northern Research and Engineering Corporation

(NREC) model, which will be discussed next. The model deals with all sources as points or a series of points. Some of the principal modifications to the original NREC model are:

1. Improved printout display;

2. For short-term concentrations, only single wind directions are input rather than a representation of wind direction variability, thus resulting in a higher concentration due to less dispersion;

3. Rather than assuming emission and meteorological data to be randomly distributed (diurnally), a large number of single, short-term values are calculated to make up the long-term concentration.

Some of the other modifications include a revised airport classification system, improved aircraft operational modes and pollutant emission rates, increased and improved details of airport representation, improved environ area source modeling and emission rates, improved representative depiction of line sources, and the inclusion of major peripheral highways.

The GEOMET model does contain a number of constraints that need to be mentioned. First, the steady-state Gaussian plume diffusion model that is used assumes steady-state conditions during the period of calculation (1 hr for short term). This assumption is not expected to give good results on a paired-comparison, hour-by-hour basis. On the other hand, the model will reproduce means and distributions reasonably well, the impacts of various types of contributing sources. Next, the model does not account for special considerations (e.g., nonmethane vs methane hydrocarbons) and reactions that occur in the atmosphere (e.g., all NO_x is not NO_2; some is still in the form of NO). Finally, the model represents line and area sources as point sources, which represents inaccuracies that increase with proximity to the sources.

The model was validated through the use of data collected at the Washington National Airport.[41] For the median and mean values of CO and particulates, the model varied from a 16% underprediction to a 36% overprediction. The 98th percentile values were overpredicted by a factor of two by the model. Both CO and NO_x have a strong tendency to overpredict in this case. Although to a smaller extent, nonmethane hydrocarbons (NMHC) and particulates also tend to overpredict in this range.

The final state-of-the-art computer model is the NREC model developed by Northern Research and Engineering Corporation under the sponsorship of the U.S. Environmental Protection Agency. Basically, the model consists of an emission and dispersion routine. The emission model accepts emissions as inputs and distributes them in time and space or accepts operational descriptions of aircraft and automotive activity and converts them into similarly distributed emissions. The dispersion model then uses the emissions, together with appropriate meteorological data, for the calculation of pollutant concentrations in or near the airport. All of the emission sources are modeled by NREC as continuous point sources. The diffusion model for atmospheric dispersion is an empirical/double-Gaussian plume solution to the dispersion equation. Finally, the concentration level at any receptor point is assumed equal to the sum of the contributions from all point sources.

The constraints of the NREC model consist of all those listed for the GEOMET model, plus one additional. NREC is limited to time periods that are much larger than the characteristic times of individual aircraft activity due to the modeling assumption of continuous sources.

NREC was validated through the use of data collected at the Los Angeles International Airport.[42] The model predicted CO emissions well, although the agreement between the modeled and observed emissions was poor for other pollutants. For particulates, NO_x, NMHC, and SO_2 emissions, the model underpredicted by factors ranging from 2.4 to 6.7. Measured concentrations of CO exceeded the model's predicted value by 2.8, although this was thought to be due to the crude manner used to model the environ emissions. The model also did poorly in predicting the various pollutant concentrations for data collected at Washington National Airport.[43]

As pointed out at the onset of this section, a number of hand computational models exist that provide a quick estimation of air quality. The Workbook of Atmospheric Dispersion Estimates by Turner[44] presents methods for estimating concentrations of air pollutants. It also discusses various special conditions and their impacts on the concentration estimates. "A Simple Method of Calculating Dispersion from Urban Area Sources" by Hanna[45] presents a simple technique for estimating pollutant concentrations due to area sources. The model assumes the surface concentration is directly proportional to the local area source strength and inversely proportional to the wind speed. The model's results compared well with those of more complex models that require the use of digital computers.

Probably the simplest and most accurate hand model is the box model. The box model is the most appropriate hand model for application to airports, since it can incorporate point, line, and area sources. One of the better box models that have been developed is used by both the Central and Western Regions of the Federal Aviation Administration. Basically, the box model assumes that all the emission sources in a defined area are dispersed into a given volume of air (i.e., a box).

For point sources, the equation is

$$C = X\left(\frac{Q}{VWH}\right),$$

where

C = concentration of pollutant (g/m^3)

X = some function of stability

Q = emission from a point source (g/sec)

V = wind velocity (m/sec)

W = width of box (m)

H = height of box (m).

For line sources, the equations becomes

$$C = X\left(\frac{Q}{VW}\right),$$

where

Q = emission from a line source (g/sec/m).

The actual model, along with a sample illustration, may be found in Appendix B.

4.1.3.2 Application

The computer models discussed in Section 4.1.3.1: Evaluation have been designed for application to large, commercial airports. The hand computational models are more suited to simpler, general aviation airports. Because of the large range of sizes of both commercial and general aviation airports, specific distinctions as to the applicability of a particular model cannot be made. In this section, the required inputs and outputs of each model, plus its primary applications and restrictions, will be explained.

The Airport Vicinity Air Pollution (AVAP) model contains a simplified input data structure that is grouped into two categories: time-independent and time-dependent variables. Within each category, there is a classification for aircraft, airport non-aircraft, and environ variables. Finally, each class of each category has data grouped according to its geometry (viz, point, finite line, and area). The user can then select computing one or any combination of pollutants (CO, THC, NO_x, and total suspended particulates), including breakdown of aircraft, airport non-aircraft, environ, and total contributions. The user can also select an hourly grid display for concentration levels of up to 175 grid points.

The data requirements of AVAP include parameters related to the layout of the airport, airport activities, and environ emissions. The data requirements are quite specific and require detailed information. The model itself generates most of the airport-related pollutant emissions.

The model was developed primarily for application to large commercial airports. Before it can be applied to another large commercial airport (its initial application was to Washington National Airport), the data requirements need to be generalized. This work is currently being completed at Argonne National Laboratory. The model also may have a useful application to large, general aviation airports. If this application is desired, additional information on training flights and detailed emission characteristics of general aviation aircraft would be required.

The Air Quality Assessment Model for Air Force Operations has basically generalized the input structure of AVAP for application to military air bases. The primary objective of developing this model was to provide air quality prediction capabilities for military air bases. The model has been designed for application to military air bases of all sizes. Since it generates both short- and long-term concentration estimates, along with the generalized input structure, the model is currently better suited than AVAP to large, commercial airports.

The data requirements for GEOMET are greater than those for AVAP, as the Airport Vicinity Air Pollution Model performs a large number of internal calculations that are required as inputs by GEOMET. As with AVAP, the data requirements for GEOMET are slanted toward Washington National Airport. GEOMET could be applied to large, general aviation airports through additional information on training flights and greater emission detail regarding general aviation aircraft. Overall, GEOMET's primary application is to large, commercial airports.

The data requirements for the NREC model are similar to those for GEOMET, although they are somewhat less detailed. As with GEOMET, the Northern Research and Engineering Corporation model was designed for Washington National Airport. Since the NREC model was the first in a line of developing models, it would not be a good choice for the prediction of air quality for either commercial or general aviation airports.

Overall, AVAP and GEOMET are good choices for application to large, commercial airports. In comparison of the two models, GEOMET provides only short-term predictions, whereas AVAP provides both short- and long-term values. The GEOMET model considers all sources as point sources or as a series of point sources. The AVAP model, however, distinguishes between point, line, and area sources. Both models assume steady state conditions for short-term calculations, and neither model accounts for atmospheric chemical reactions.* In addition, the AVAP model has a more detailed representation of aircraft operational modes [and non-airport source emissions]. As discussed above, both need to be generalized to eliminate their biases toward the design of Washington National Airport. Also, these models need additional input relative to general aviation airports before they can be applied to this type of airport. The Air Force model would also make a

*At present, there is no validated photochemical model for estimating photochemical oxidants.

good choice in the near future, since its input structure has already been generalized. If this model is applied, a new set of emission characteristics must be input for commercial aircraft to replace the existing ones for military aircraft. This information is readily available, and the changes required to apply the Air Force model to commercial airports could be made quickly.

Of the hand models described in Section 4.1.3.1, the box model explained in Appendix B is the best choice for the approximation of air quality concentration levels for small, simple airports. A good rule of thumb when deciding whether to use the box model or a computer model would be to compute the concentration levels generated by the airport with the box model. If the conservative estimate (as explained in Appendix B) comes close to the standard, a computer model should be incorporated. Typically, an airport would have to be on the order of a large, commercial airport before the generated concentrations would approach the standards. The hand model does serve as a fast device for use by EIS reviewers to check the results of the computer models. Normally, though, it should not be applied to an airport that generates a significantly large quantity of pollutants.

4.1.4 Abatement Strategies

Abatement strategies come into focus first at the construction phase and then once again during the operational phase of an airport project. The Airport and Airway Development Act of 1970 states it to be ..."national policy that airport development projects shall provide for the protection and enhancement of the natural resources and the quality of environment of the nation."[46] To meet this objective, FAA has published an advisory circular dealing with airport construction controls to prevent air and water pollution.[47]

The first control discussed by the advisory circular to reduce air pollution during construction addresses open burning. If the state or local area where the project is located does not deal directly with this, the following restrictions should be considered:

1. Do not permit tires, oils, asphalt, paint, and coated metals in combustible waste piles;

2. Do not permit burning within 1000 ft of a residential or built-up area or within 100 ft of standing timber or flammable growth;

3. Do not permit burning when prevailing winds are toward a nearby town or built-up area;

4. Do not permit burning during local air inversions or other local climatic conditions that would result in a pall of smoke over a nearby town or built-up area;

5. Restrict the size and number of fires to avoid the danger of brush or forest fires.

In some instances, one of the following alternatives may be incorporated in lieu of open burning:

1. Spoil materials may be buried outside of airport construction graded areas;

2. Wood may be salvaged for firewood or commercial use, such as mulch;

3. Logs, brush, or other wooden materials may be removed to an authorized disposal area or disposed of to the general public at no charge.

In Section 4.1.2, the sources of air pollution during construction are listed. For each of the sources, abatement strategies exist for reducing or eliminating the problem. The following strategies should be considered and evaluated relative to the type of project at hand:

1. Drilling apparatus equipped with water or chemical dust controlling systems;

2. Exposing a minimum area of land;

3. Applying temporary mulch with or without seeding;

4. Use of water sprinkler trucks;

5. Use of covered haul trucks;

6. Use of stabilizing agents in solution;

7. Use of dust palliatives and penetration asphalt on temporary roads;

8. Use of wood chips in traffic and work areas;

9. Use of vacuum-equipped sandblasting system;

10. Use of plastic sheet covering;

11. Restricting the application rates of herbicides;

12. Equipping bituminous mixing plants with dust collectors;

13. Delaying operations until the climate or wind conditions dissipate or inhibit the potential pollutants.

The abatement strategies implemented during the construction phase are fairly straightforward and principally a matter of enforcement. The EIS reviewer can list techniques that are to be used by the contractor to minimize air pollution, but they are of little value unless implemented.

The operational phase of an airport project, on the other hand, requires a larger set of more complicated abatement strategies. Section 4.1.2 lists the seven major sources of air pollution at an airport. Each of the sources has a number of abatement strategies associated with it. The primary source, aircraft engine exhaust emissions, has been given close attention in the EPA report, "Aircraft Emissions: Impact on Air Quality and Feasibility of Control."[48] Much of the information contained in the report is based upon research completed by Northern Research and Engineering Corporation in their report entitled "Assessment of Aircraft Emission Control Technology."[49] Basically, the EPA report breaks down aircraft into four categories, three for turbine engines and one for piston engines. For the three turbine categories, six modifications for existing engines and two designs for future pollutant levels, as percentages of current levels, are estimated. Along with these estimates, development costs and time scales are predicted. For the one category of piston engines, eight modifications and one future engine design are evaluated. This type of information is extremely helpful to the EIS reviewer when evaluating the time scale incorporated into an EIS for the implementation of air pollution control devices and their effectiveness.

Besides engine modifications and redesigns, emissions can also be controlled through modification of ground operations. The EPA report evaluates six such modifications, in terms of the reduction of carbon monoxide and hydrocarbon emissions, implementation time, initial cost, and annual operating costs. Once all of the abatement strategies for design and ground operation had been compiled, EPA evaluated them according to a potential benefit factor (PBF).[50] The factor is a function of the net emission reduction resulting from a particular control strategy averaged over the next 20 years, and divided by the cost. The PBF values led to the following conclusions concerning abatement strategies:

1. For ground operations, the increase in idle speed and the use of minimal engines for taxi is the most cost-effective method of reducing hydrocarbon and CO emissions from turbine engines;

2. For engine design, the incorporation of emission control methods into the design of new engines is the most cost-effective method of overall aircraft emission control;

3. Control of the fuel-air ratio is the most cost-effective method of reducing hydrocarbon and CO emissions from piston engines;

4. Retrofits of small turbine engines (such as business jets) is a more cost-effective method of NO_x control compared to retrofit of other turbine engines.

The second source of emissions, ground service vehicles, can be controlled in a variety of ways. First, the vehicles could be modified to burn propane gas, thereby reducing their emissions. On the other hand, pollution control devices similar to those used on automobiles could be incorporated. These are not currently required, since this type of vehicle is considered an "off-the-road vehicle" and therefore not controlled. The emissions generated by access traffic are currently being reduced through the installation of control devices on automobiles. These emissions could be reduced further through a decrease in congestion and the provision of alternative modes of transportation.

Engine testing and maintenance facilities may be controlled through engine modifications as discussed above. It naturally follows that as the engines become "cleaner," the maintenance facilities will generate less air pollution. These facilities may also be modified through the use of test cells equipped with afterburners and catalytic convertors. The pollutants generated by the heating and air-conditioning plants are a result of such things as fuel type, building size, and thermal insulation. Normally, these decisions are economically based, therefore making environmental considerations difficult to evaluate. A fuel-handling and fuel-storage system generates a significant quantity of HC. This leakage can be most readily controlled through the installation of a vapor recovery system. Finally, the pollutants generated by the miscellaneous sources, although minor in comparison with the other sources, can be controlled with systems similar to those in industrial applications.

The EIS reviewer should be knowledgeable as to the sources of air pollutants related to an airport project and the abatement strategies available to control those sources. This information is helpful not only in checking that an EIS has considered abatement strategies for all sources, but also for suggestions made by the reviewer as to the available control devices for sources not covered in the EIS.

4.2 NOISE IMPACT

4.2.1 Federal, State, and Local Standards

The Noise Control Act of 1972 established a national policy "to promote an environment for all Americans free from noise that jeopardizes their public health and welfare."[51] The Act specifies that the federal government is primarily responsible for noise source emission control, while the state and local governments are responsible for the control of the use of noise sources and the levels of noise permissible in their environment.

To satisfy the requirements of Congress under the Act, the U.S. Environmental Protection Agency published two reports. In July, 1973, "Public Health and Welfare Criteria for Noise" was published to provide descriptive data on the effects of noise for various levels and exposure situations.[52] Secondly, U.S. EPA published "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety" in March, 1974.[53] This document provides information on the levels of noise required to protect the public health and welfare with an adequate margin of safety. In Table 6 the noise levels published in the second report are presented. These levels are subject to a number of definitions and qualifications presented in the publication.

In Table 6, $L_{eq}(24)$ represents sound energy averaged over a 24-hour period. L_{dn} is virtually the same as L_{eq} with a 10 dB nighttime weighting. Also, EPA has determined that for the purpose of hearing conservation alone, an L_{eq} of 70 dB averaged over a 24-hour day for a period of 40 years is required.

Note that the U.S. Environmental Protection Agency does not present these levels as standards, as the levels do not take account of cost or feasibility. The U.S. EPA does believe that to protect an individual from adverse health and welfare effects created by noise (listed in the first column of Table 6), these stated levels of environmental noise must not be exceeded.

In 1969, the Federal Aviation Administration (FAA) promulgated Part 36 of the Federal Aviation Regulations (FAR).[55] FAR Part 36 (Noise Standards: Aircraft Type Certification) sets noise limits for specific aircraft. The regulation defines particular locations with respect to the airport runway where measurements are to be taken. The regulation imposes further restrictions ensuring that the aircraft will become progressively quieter in the future.

Table 6. Summary of Noise Levels Identified as Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety[54]

Effect	Level	Area
Hearing loss	$L_{eq}(24) \leq 70$ dB	All areas
Outdoor Activity Interference and Annoyance	$L_{dn} \leq 55$ dB	Outdoors in residential areas and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{eq}(24) \leq 55$ dB	Outdoor areas where people spend limited amounts of time, such as school yards, play grounds, etc.
Indoor Activity Interference and Annoyance	$L_{dn} \leq 45$ dB	Indoor residential areas
	$L_{eq}(24) \leq 45$ dB	Other indoor areas with human activity such as schools, etc.

The FAA has also adopted two other FARs and two advisory circulars (ACs) related to flight and operational noise controls. FAR 91.55 prohibits flight at speeds in excess of Mach 1 and thereby prevents the occurrence of sonic booms unless a specific authorization is given.[56] FAR 91.87 regulates operation at airports with operating control towers.[57] It specifies that the minimum altitude for turbine-powered or large aircraft is 1500 feet above the surface of the airport, except when lower altitudes are necessary for take-off or landing. It further requires that such aircraft when approaching to land remain on or above the Instrument Landing System (ILS) or Visual Approach Slope Indicator (VASI) glide slopes, if available, until a lower altitude is necessary for a safe landing. In addition, it requires pilots of these aircraft to use, whenever possible, the preferential noise abatement runway assigned by Air Traffic Control (ATC).

AC 90-59 describes the FAA "keep-em-high" program wherein controllers issue clearances to keep high performance aircraft as high as possible for as long as possible.[58] This program was initially introduced for the purpose of collision avoidance, but it also provides some noise relief by preventing unnecessary low altitude flight. Finally, AC 91-36 encourages pilots operating fixed or rotary wing aircraft under Visual Flight Rules (VFR) to fly at not less than 2000 feet above the surface over noise sensitive areas.[59]

The 1971 State of California Airport Noise Standard provides for the only comprehensive long-range noise planning in the country.[60] The only such plan that is known to exist is the one for the Orange County (California) Airport.[61]

Another tool available to the airport proprietors on the state and local levels is to restrict aircraft that create noise above a specified level from using any particular runway. The Port of New York Authority, for example, has a noise limit of 112 PNdB (approximately 97 dBA) as measured at any of its monitoring stations. The Los Angeles International Airport, since December 31, 1974, permits only aircraft that comply with FAR Part 36 to operate there.

4.2.2 Identification of Sources

Limited levels of noise may be generated during the construction of an airport. This noise results from construction activities such as excavation, drilling, blasting, etc. Since the construction requirements and characteristics of the area vary for each airport project, this source of noise must be reviewed individually for each airport environmental impact statement.

The main source of noise generated during the operational phase of an airport is aircraft noise. Other relatively minor sources of noise are airport support vehicles and equipment, aircraft engine maintenance and testing, and vehicles using airport access highways. The noise generated on the highway facilities can be predicted by any number of available highway noise models.[62]

The primary sources of noise on a commercial jet aircraft are engines, boundary layer pressure fluctuations, and internal equipment. The noise generated by the engines occurs at the inlets and the exhaust regions of the fan exit ducts and the primary nozzle. Pressure fluctuations in the fuselage boundary layer excite structural components that in turn radiate acoustics energy into the aircraft interior. Internal equipment sources of noise are blowers and auxiliary power plants with pumps as a minor source.

The two principal sources of noise in a jet engine are the jet exhaust and the fan/compressor. The jet noise is radiated mainly toward the rear of the engine. The fan/compressor noise, on the other hand, radiates forward out the engine inlet and out through the fan exhaust duct. On takeoff, the jet noise contributes measurably to the overall noise levels generated. During landing approaches, the fan whine from the inlet and discharge ducts generates higher noise levels than the jet exhaust. In the early turbojet engines, the jet noise component was dominant throughout all power settings. The later high bypass-ratio turbofan engines generate significantly reduced jet noise levels. Still, for all types of jet engines, both sources of noise are significant when determining the total jet engine noise levels.

The noise associated with propeller aircraft with either piston or turbine engines is produced principally by the propellers. The noise from the engine and exhaust may contribute measurably to the total noise generation of some types of propeller aircraft, but is generally masked by the propeller noise. The helicopter, on the other hand, generates a unique noise signature. The main rotor, rotating relatively slowly, generates a distinctive low frequency throbbing sound. Because of its low frequency, it is extremely difficult to reduce.

Overall, the noise levels to which individuals or parcels of land are exposed are based upon three variables. The first variable is the distance between the point of observation or exposure and the aircraft. Next is the aircraft's operating mode, or the engine thrust level. Finally, the atmospheric conditions are taken into account. Using these three variables, noise contours can be calculated and then related to affected land use.

A summary of the steps required for airport noise analysis is presented in Fig. 2. It is included to provide the reviewer with a one-page summary of the process described in the remainder of this section.

4.2.3 State-of-the-Art Assessment Techniques

Over the past two decades, numerous noise exposure schemes have been proposed. Recently, more emphasis has been placed on determining the noise exposure with greater accuracy. In the meantime, our understanding of how noise exposure relates to noise impact or community response has lagged far behind. This section presents the five most common noise rating systems used in the United States for describing aircraft noise exposure in the vicinity of airports.

Approximately twenty years ago the Composite Noise Rating (CNR) system was first proposed. Initially, it was utilized to assess community response to jet aircraft noise in the vicinity of Air Force bases. In 1964 a Land Use Planning Manual[63] presented a modified version of CNR for use on commercial airports. The CNR has been used by many airports, communities, airport planners and engineers, and land use planners for a variety of planning purposes, and by the Federal Housing Administration (FHA) in considering the guarantee of loans for new residential tract construction near airports. The CNR methodology is acceptable to both EPA and FAA for environmental impact statements.

The Noise Exposure Forecast (NEF) technique is an outgrowth of the CNR procedure. The two techniques give similar results and are both acceptable to EPA and FAA. Both CNR and NEF may prove adequate for determining changes in environmental impact noise, but CNR and NEF are difficult to measure

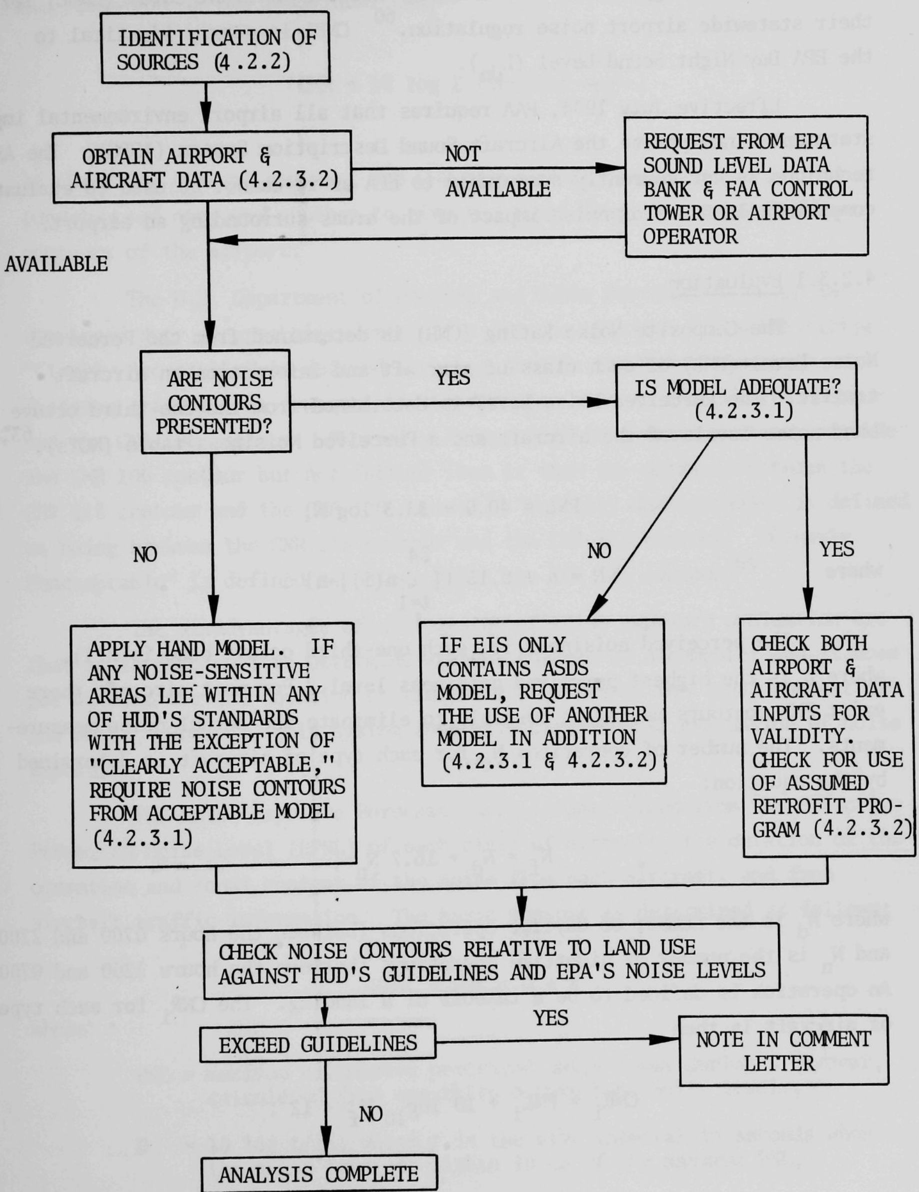


Fig. 2. Steps For Airport Noise Analysis

directly. Thus, the State of California adopted a slightly modified noise exposure methodology termed the Community Noise Equivalent Level (CNEL) for their statewide airport noise regulation.[60] CNEL is nearly identical to the EPA Day-Night Sound Level (L_{dn}).

Effective July 1974, FAA requires that all airport environmental impact statements incorporate the Aircraft Sound Description System (ASDS). The ASDS technique is not currently acceptable to EPA as it cannot be used to evaluate compatible land use or noise impact of the areas surrounding an airport.

4.2.3.1 Evaluation

The Composite Noise Rating (CNR) is determined from the Perceived Noise Level (PNL) of each class of aircraft and information on aircraft traffic. The Perceived Noise Level is determined from the one-third octave band noise levels of the aircraft and a Perceived Noisiness table (NOYs).[63,64]

$$PNL = 40.0 + 33.3 \log N,$$

where

$$N = n + 0.15 \{[\sum_{\ell=1}^{24} n(i)]-n\} .$$

The perceived noisiness for each one-third octave band is n(i), where n is the highest perceived noisiness level. For most aircraft there exist PNL contours making it possible to eliminate the actual noise measurements. The number of operations N_f for each type of aircraft is determined by the equation:

$$N_f = N_d + 16.7 N_n ,$$

where N_d is the number of daytime operations (between the hours 0700 and 2200) and N_n is the number of nighttime operations (between the hours 2200 and 0700). An operation is defined to be a takeoff or a landing. The CNR_i for each type of aircraft is then

$$CNR_i = PNL_i + 10 \log_{10} N_f - 12 .$$

The Composite Noise Rating for all aircraft is given by the logarithmic summation of the individual CNR_i:

$$CNR = 10 \log \sum_i [\text{antilog} \frac{CNR_i}{10}] \ .$$

If there are several runways, the CNR contours from each runway must be superimposed over one another to give the total Composite Noise Rating contours of the airport.

The U.S. Department of Housing and Urban Development (HUD) has developed four acceptability categories for use with the CNR noise rating. "Clearly Acceptable" is defined as being outside the CNR 100 contour at a distance greater than or equal to the distance between the CNR 115 contour and the CNR 100 contour. "Normally Acceptable" is defined as being outside the CNR 100 contour but not farther from it than the distance between the CNR 115 contour and the CNR 100 contour. "Normally Unacceptable" is defined as being between the CNR 115 contour and the CNR 100 contour. "Clearly Unacceptable" is defined as being within the CNR 115 contour.[65]

The disadvantages of this system of noise exposure evaluation are that it is difficult to determine without the aid of a computer and it does not account for the duration of time of the events or the tonal content of the noise. However, this system does give a reasonable evaluation of noise exposure.

The Noise Exposure Forecast (NEF) is determined from the Effective Perceived Noise Level (EPNL) of each class of aircraft, the duration of the operation and tonal content of the noise from each aircraft, and from aircraft traffic information. The basic measure is determined as follows:

$$EPNL = PNL + D + F \ ,$$

where

PNL = maximum calculated perceived noise level during a flyover, calculated from one-third octave band noise levels,

D = 10 log t/15; where t is the time interval in seconds when the noise level is within 10 dB of the maximum PNL,

F = correction for the presence of discrete frequency components; the correction is tabulated according to the one-third octave band in which the tone lies and the extent to which the tone level exceeds the mean level in the adjacent bands.

The Noise Exposure Forecast for each type of aircraft is given by the equation:

$$NEF_i = EPNL + 10 \log N_f - 88 ,$$

where N_f is defined as it was for the Composite Noise Rating.

The Noise Exposure Forecast for a specific type of aircraft, i, on flight path, j, can also be expressed:

$$NEF(i,j) = EPNL(ij) + 10 \log \left[\frac{n_D(ij)}{20} + \frac{n_N(ij)}{1.2}\right] - 75 ,$$

where $n_D(ij)$ and $n_N(ij)$ are the number of operations, for daytime (0700-2200) and nighttime (2200-0700), respectively, of aircraft class, i, on flight path, j. The total Noise Exposure Forecast at a given ground position is determined by the summation of all the individual NEF(ij) values on an energy basis:

$$NEF = 10 \log \sum_i \sum_j \text{antilog} \left(\frac{NEF(ij)}{10}\right) .$$

The acceptability criteria according to HUD is the same for the NEF contours 30 and 40 as for the CNR contours 100 and 115, respectively. The region outside the NEF 30 contour at a distance greater than or equal to the distance between the NEF-30 and NEF-40 contours has a "Clearly Acceptable" noise exposure due to aircraft. The region outside the NEF-30 contour at a distance less than the distance between the NEF-30 contour and NEF-40 contours has a "Normally Acceptable" noise exposure. The region between the NEF-30 and NEF-40 contours has a "Normally Unacceptable" noise exposure. Finally, the region inside the NEF-40 contour has a "Clearly Unacceptable" noise exposure.

The advantage of the Noise Exposure Forecast method over the Composite Noise Rating is that NEF accounts for the noise duration of each flight and tonal content. However, the NEF is even more difficult to calculate than is the CNR. Also, since only two contours (NEF 30 and 40) are usually generated, the actual noise exposure of a particular area not on one of these contours cannot be derived directly from the NEF ratings.

Figure 3 provides example EPNL contours for two types of aircraft currently in service. The takeoff and landing contours for the two engine turbofan aircraft (Boeing 737 and Douglas DC-9) are given in Fig. 3-a, and the EPNL contours for the four-engine propeller aircraft (Douglas DC-6 and DC-7) are given in Fig. 3-b.

The Community Noise Equivalent Level (CNEL), developed by the State of California, is determined from the maximum A-weighted sound level of each operation, the time duration of that operation, and number of operations per day, evening, and night.[67] The Single Event Noise Exposure Level (SENEL) is determined from the maximum A-weighted noise level (NL_{max}) and the time duration by the equation:

$$\mathrm{SENEL} = NL_{max} + 10 \log \tau/2 ,$$

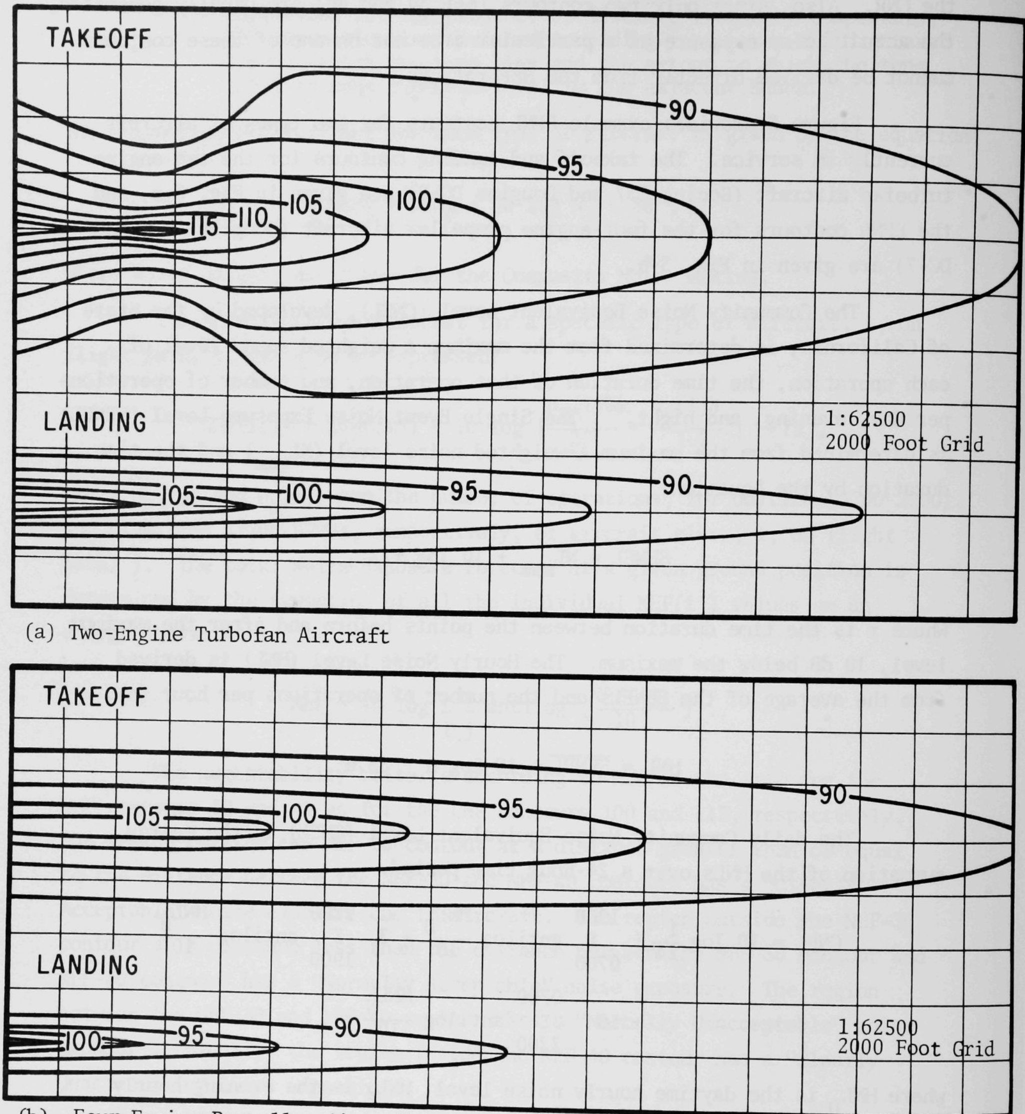
where τ is the time duration between the points before and after the maximum level, 10 dB below the maximum. The Hourly Noise Level (HNL) is derived from the average of the SENELs and the number of operations per hour (n).

$$\mathrm{HNL} = \overline{\mathrm{SENEL}} + 10 \log n - 35.6 .$$

The daily Community Noise Equivalent Level (CNEL) is the energy summation of the HNLs over a 24-hour time period.

$$\mathrm{CNEL} = 10 \log \frac{1}{24} \{ \sum_{0700}^{1900} \text{antilog} \frac{HNL_D}{10} + 3 \sum_{1900}^{2200} \text{antilog} \frac{HNL_E}{10}$$
$$+ 10 \sum_{2200}^{0700} \text{antilog} \frac{HNL_N}{10} \} ,$$

where HNL_D is the daytime hourly noise level, HNL_E is the evening hourly noise level, and HNL_N is the nighttime hourly noise level. By this method of summation the evening flights (HNL) are penalized by approximately 5 dB and the nighttime flights (HNL) are penalized by 10 dB.



(a) Two-Engine Turbofan Aircraft

(b) Four-Engine Propeller Aircraft

Fig. 3. Example EPNL Contours[66]

The CNEL system in California now recommends a limit of 70 dB for residential communities around existing airports. In the future, a maximum CNEL of 65 dB will be the limit for residential communities around all airports in California.

The CNEL system has the advantage that it can be easily monitored and therefore enforced. The CNEL is easier to compute than NEF and CNR because it does not require the use of NOYs (PNL and EPNL) tables or tonal corrections. However, it still requires the use of a computer to generate contours.

The Day-Night Sound Level (L_{dn}), developed by the U.S. Environmental Protection Agency, requires the maximum A-weighted sound level as observed on a slow time characteristic (L_{max}), the time duration between the two points 10 dB below the maximum sound level (τ), and the number of operations per time of day (N).[52] The sound exposure level (L_{ex}) is approximately equal to the sum of the maximum sound level and a time duration correction factor:

$$L_{ex} = L_{max} + 10 \log \tau/2 .$$

The number of operations per time of day is:

$$N = (N_d + 10\ N_n) ,$$

where N_d is the number of daytime operations (0700-2200) and N_n is the number of nighttime operations (2200-0700), which penalizes the noise levels during the night by 10 dB. The Day-Night Sound Level is determined from the energy mean of L_{ex} and from a log function of N.

$$L_{dn} = \overline{L_{ex}} + 10 \log N - 49.4 .$$

The Day-Night Sound Level system, like the CNEL, has the advantage of being easily monitored and enforced. However, the availability of computer programs for generating L_{dn} contours is limited at present since the system is relatively new.

The Aircraft Sound Description System (ASDS), developed by the Federal Aviation Administration, is a prediction of the time a region is exposed to noise levels 85 dBA or greater due to aircraft noise.[68] The parameters used to compute the ASDS time constant are the observed distance from the noise source to the listener at which the noise level is 85 dBA (D), the peak noise level (i), the speed of the aircraft (V), the area of exposure to a certain noise level or greater (A_i), and the point of closest approach (H). The time constant for each operation (T_c) is computed by the equation:

$$T_c = \sum_{i=86}^{115} T_i \left[\frac{A_{(i-1)} - A_i}{A_{85}}\right] ,$$

where A_i is the area contained within the range of maximum noise level i. T_i is the amount of time the noise level is above 85 dBA with a peak of i and is given by the equation:

$$T_i = \frac{2D}{V} (1 - 10^{2K})^{1/2} ,$$

where

$$K = \frac{85 - 1}{26.6} .$$

The summation extends from 86 dBA to 115 dBA, as a noise level of 85 dBA is the established lower boundary for this system and above 115 dBA the area weighting factor diminishes rapidly. The total time-exposure of a particular area and time period is the sum of the time constants T_c for all events during that time period.

Until this system is further developed to the point where the actual noise-level-time history can be readily determined, a time constant (T_c) of 15 seconds for takeoff operations and a time constant of 10 seconds for landing operations are being used. These time constants have been calculated from observed data on a variety of aircraft to be a conservative approximation to the noise exposure for that event.

From the T_c values and information on aircraft traffic, a contour map of the noise exposure in the area of the aircraft can be generated by the use of computer programs. A single value called the "situation index" depicting the overall situation of a given area can also be determined by the same data. The situation index (SI) is calculated by the equation

$$SI = \sum_{j=1}^{m} \sum_{j=1}^{n} A_{ij} N_{ij} T_c^{\ i} \text{ (acre-min.)} ,$$

where A_{ij} is the area exposed to 85 dBA or higher for the jth aircraft in the ith type of event, and N_{ij} is the number of events for type i by aircraft j.

The advantage of the ASDS is that it calculates the total area around the airport that is exposed to 85 dBA or greater. This system, however, does not give any information on the exposure to other noise levels above or below 85 dBA, nor are there guidelines on the interpretation and acceptability of the contours or the situation index. Therefore, it is not possible to determine the noise impact on the community by this method.

To provide the EIS reviewer with a quick, hand-computational method with which to predict noise levels, a hand model developed by the U.S. Department of Housing and Urban Development is presented in Appendix C. This model allows the reviewer to check noise levels presented in an EIS, and also to calculate noise levels where none are contained in the EIS.

4.2.3.2 Application

The five community noise prediction models discussed in Section 4.2.3.1 all deal with the term "noise exposure" to indicate the existence of a noise environment regardless of whether or not there are people present within the environment. The term "noise impact" is used to mean the combined result of a noise environment, the presence of people within the environment, and the degree of noise sensitivity associated with their activities. Note that the current ASDS technique cannot be used to determine noise impact and thus is not suitable for reviewing environmental impact statements. The Day-Night Noise Level (L_{dn}) will eventually be the principal methodology used by EPA. However, at the present time there are not sufficient data available in L_{dn} format to conveniently generate L_{dn} contours around an airport under study. The Office of Noise Abatement and Control (ONAC) of EPA is building a centralized data bank that will eventually be used for generating L_{dn} contours for all airports. Many private organizations and government agencies now have the capability of generating NEF contours; thus we may anticipate that most environmental impact statements will contain the NEF methodology and the ASDS methodology (the latter required by FAA).

The four acceptable noise exposure methodologies give similar results. In general, the relationship between them is:

$$L_{dn} \simeq \text{CNEL} \simeq \text{NEF} + 35 \simeq \text{CNR} - 35 \; .$$

For reviewing an EIS, this relationship may be used to determine L_{dn} values from other methodologies.

There are two distinct types of data that enter into airport noise exposure calculations. The first type includes those elements of data that describe the airport facility and the operation of aircraft in the vicinity of that facility. The second type deals with data that describe the sound level characteristics of specific aircraft when they are operated in an equally well-specified manner.

The necessary elements of the first data set (airport data) are:

1. Airport configuration in terms of the location of the runways with respect to a given reference point;
2. Location of the landing thresholds and start of takeoff roll on each runway. If there are several thresholds or start-of-roll points corresponding to different types of aircraft, these must be noted;
3. Flight tracks; i.e., the projection on the ground of the paths followed by arriving and departing aircraft;
4. Restrictions due to airspace management, curfews, etc;
5. Number of operations by type of operation (landing, takeoff, touch-and-go), by aircraft type, runway, time of day, and flight track;
6. Seasonal variations in basic facility operational patterns;
7. Flight profiles; i.e., aircraft altitude as a function of distance from start-of-roll or distance to touchdown. (Flight profile descriptions imply a knowledge of the parameters that affect aircraft performance, including aircraft weight, thrust, flap management, etc.)

The elements of the second data set (aircraft data) include the relationships of aircraft sound level to the distance between source and receiver for both landing and takeoff operations, along with the effects of engine power level changes on the source sound levels.

In the near future, EPA/ONAC will supply all of the aircraft sound level data required for EIS reviews. At this time, the EPA/ONAC is developing an aircraft sound level data bank. The data bank contents can be used with any of the available computer programs, since only the data format varies between programs. The sound level data bank is a continuing effort and will be broadened to include all classes of aircraft. The data bank was started because the EPA recognizes a need to use a "standardized" set of aircraft sound level data and because it is not within the province of the airport operator to supply such data. Similarly, it may be unreasonable to expect the airport operator to be a good source of aircraft performance data, as the specifics of aircraft performance are not generally within the realm of the airport operator's sphere of cognizance. Hence, EPA/ONAC has also undertaken the development of a methodology that can be used to determine flight profiles as a function of basic aircraft characteristics and operating environment (takeoff gross weight, runway elevation, outside air temperature, etc.) This methodology should be operable in 1976.

Two additional concepts have been developed for the purpose of aircraft noise impact evaluation. Although these concepts have not been officially adapted by the U.S. EPA, they are currently favored by ONAC within EPA.

The first concept is the Fractional Impact (FI), which is simply the difference between some defined reference noise level and the noise level generated at the same location by aircraft, divided by 20. All of the noise levels in the FI are in L_{dn} units. The reference level may be a criterion noise level or a background level. Criterion levels are usually assigned to various types of land uses based upon compatibility with noise. EPA's recommended level for residential development of 55 L_{dn} is a good example. Background levels are the measured or estimated sound levels present in a particular environment or study area. The following example is provided for the calculation of the FI:

Aircraft emission level = $80\ L_{dn}$

Criterion level for residences = $\underline{55\ L_{dn}}$

L_{dn} exceeded by aircraft = $25\ L_{dn}$

$25\ L_{dn} \div 20 = 1.25$ = Fractional Impact

The use of a constant divider of 20 reflects consideration of recent evidence strongly supporting the contention that both human annoyance and speech interference are arithmetically direct functions of the amount by which background levels are exceeded. When the background is exceeded by 20 L_{dn}, the intruding source is consistently identified as being intolerable. This factor has also been applied in determining fractional impact from criterion levels to make criterion and background level fractional impact analyses more compatible.

The second concept, Noise Units (NI), is simply the affected population multiplied by the Fractional Units. If the affected population from the previous example were 1000, the Noise Units would therefore be 1250 (1000 x 1.25).

These two concepts provide a simple method for relating noise exposure levels to noise impacts for a given population participating in a given activity. Although the EPA has not yet promulgated noise standards for aircraft, these concepts may be applied to background levels or EPA's recommended criteria.

4.2.4 Abatement Strategies

Strategies to reduce the noise generated by aircraft may be grouped into two major categories: aircraft or engine modifications, and flight and operational modifications. The attractiveness of the procedural (flight and operational) methods of noise reduction is that they can be accomplished in a short period of time (0 to 5 years) and at a low cost (often no cost). This is in contrast to aircraft or engine modifications, or land use conversions, which normally require more time to implement at a substantial cost. Further discussion of land use control strategies that aim to lessen impact by having less sensitive uses near the airport, can be found in Section 4.5: Land Use Impact.

Engine or aircraft modifications include a number of programs that are currently under consideration. The first program is the application of sound absorptive material (SAM) to the nacelles of all narrow body jet transports. This will reduce sound levels approximately 3 EPNdB during take-off and 10-15 EPNdB during approach. Although the gains are significant, the costs may run up to $1 million per aircraft for installation and may increase the operating cost by 9%.[69] The "Quiet Engine" program may reduce aircraft noise approximately 10 EPNdB below today's quietest aircraft (747 and DC-10). The retrofit of the engines would cost up to $4 million per aircraft, although the amount will be less for new aircraft. When reviewing an EIS, one should take care to determine whether the EIS has assumed that some or all of the present aircraft fleet will be retrofitted to be quieter at some future date.

It is important to recognize that flight noise controls usually apply to a single aircraft, and airport operational noise controls usually apply to a single airport. But the single aircraft and the single airport are merely single parts of a total system that, while providing air transportation to the nation, causes people to be exposed to high levels of noise. Each individual aircraft engine makes noise; the way in which the aircraft is flown can increase or reduce the level of noise at a point on the ground. Flight or airport procedures alone cannot be expected to totally solve the noise problem. At best they must be considered as only two elements of what must be a more comprehensive plan that also includes controls on the source of the noise and the location of people exposed to noise. In addition, one should keep in mind that flight safety is of paramount importance in developing flight and operational noise controls.

Maximum angle (full power) climbouts and power cutback climbouts are two technically feasible noise abatement procedures in current use for takeoffs. The choice of which procedure is better (or which cutback altitude is best) depends on the location of noise sensitive areas with respect to the departure runway. The maximum angle climbout is most beneficial for far-downrange (more than approximately 10 miles from the airport) noise problems. The power cutback climbout is most beneficial for near-downrange (approximately 4 to 10 miles from brake release) noise problems.

Several procedures have been proposed to reduce approach and landing noise. The most important of these are:

1. Reduced flap settings;
2. Increased initial approach altitudes;
3. Higher glide slopes;
4. Two-segment approaches;
5. Decelerating approaches; and
6. Thrust reverse limitations.

The first procedure for reducing landing noise, reduced flap settings, provides meaningful noise relief and is technically feasible. The "keep-em-high" philosophy by increasing initial approach altitudes provides meaningful noise relief of up to 10 dBA on the ground at distances greater than five miles from touchdown. Glide slope angles of 3° are standard for new installations and result in less noise than lower glide slope angles, yet a majority of existing glide slopes are lower than 3°. Glide slope angles of up to 3.5° reduce noise even further and are in use at a few locations to provide terrain clearance.

Two-segment approaches provide significant noise reductions, are technically feasible, and are already in use in some segments of the air transportation system during Visual Flight Rule (VFR) weather conditions. Some type of guidance equipment appears to be necessary and is available for VFR conditions. Completion and evaluation of the current National Aeronautics and Space Administration (NASA) test program should result in equipment suitable for Instrument Flight Rules (IFR) two-segment approaches. In a decelerating approach, the aircraft starts at a high speed and then thrust is reduced to nearly flight idle. The aircraft then slows down during the approach because of aerodynamic drag. The decelerating approach is technically feasible but has not as yet been proven adequate for widespread routine use. Finally, the extensive high power use of thrust reversers for landing on long, dry runways where there is a sideline noise problem and no air traffic control urgency appears to be unnecessary and undesirable.

The tradeoff between sideline thrust reverse noise and aircraft taxi noise is one that can be made only at the local level.

Since the noise generated by propeller-driven aircraft and helicopters is normally dominated by jet aircraft noise, noise abatement procedures for these types of aircraft are not discussed in detail. The following summary includes operational techniques useful in abating noise from these aircraft:

1. Departure procedures involving the steepest possible climbout angles provide the best possible noise relief for general aviation and helicopter takeoffs;

2. Approach procedures using the steepest possible angle provide the maximum noise relief on landing (helicopters should avoid the blade slap regime). Visual Approach Slope Indicators (VASIs) set for an angle of 4° to 5° could be helpful for general aviation landing runways; and

3. Enroute altitudes as high as possible will minimize noise away from airports and heliports.

In addition to the abatement strategies discussed above, an individual airport may also enforce certain noise controls. These may include schedule limitations, aircraft type limitations, night curfews, aircraft weight or trip length limitations, preferential runways and flight paths, engine runup (testing) restrictions, or noise barriers. Economic incentives, monitoring and enforcement, and airport certification may also be employed to decrease noise levels generated at a given airport.

4.3 WATER AND WASTEWATER IMPACT

4.3.1 Federal, State, and Local Standards

The principal legislation regarding water quality control at the federal level is the Federal Water Pollution Control Act, as amended.[70] The Act, which is administered by the Environmental Protection Agency, regulates point source discharges into navigable waters. The water quality standards and effluent limitation guidelines affect airport operation inasmuch as the airport is a point source of wastewater. If the airport chooses to treat its own wastewater, it will be directly affected by the federal standards and must obtain the proper permits. If the airport chooses to connect into a nearby municipal treatment system, the wastewater stream must be pretreated, if necessary, for compatibility with the treatment works. In particular, industrial wastewater discharged by an aircraft maintenance and overhaul base must be pretreated before being mixed with domestic wastewater.

The Act mandates that the states pass their own water quality and wastewater management laws for intrastate waters. The states are to set water quality standards for all bodies of water in the state, subject to EPA approval. Until each state had its own water quality control laws approved by the U.S. Environmental Protection Agency, the federal law was administered by the EPA in each state. The state laws must cover all the same issues as the Federal Water Pollution Control Act. Although the specific values of the standards can vary from state to state, they must be at least as stringent as the Federal standards. The states may also assume the issuance of permits as described in Title IV of the Act. If the state chooses not to qualify for EPA certification to issue discharge permits under the Act, then it is possible that two permits, one state and one federal, would be required. It is necessary for the reviewer to know whether the federal government, state government, or both, issue permits for discharge into navigable waters. The reviewer must be aware of the standards for the body of water into which the airport plans to discharge wastewater, as well as the effluent quality limitations. States may also have laws specifying the use of certain erosion and sedimentation control practices during construction.

According to the Airport and Airway Development Act,[71] the governor of the state must certify in writing that the project in question "will be located, designed, constructed, and operated so as to comply with applicable air and water quality standards." This certification should be included in the airport project environmental impact statement for projects involving airport location, a major runway extension, or runway location.

Although the major responsibility for enforcement of water quality standards rests with the state once the state laws are approved by the EPA, authority can be delegated to municipalities and special districts. As an example, in Cook County, Illinois, the Metropolitan Sanitary District of Greater Chicago, the State of Illinois, and the City of Chicago work together to enforce the water quality standards. The State has passed its own water pollution control act and is ultimately responsible for enforcement. The Metropolitan Sanitary District monitors all discharges within its district and ensures maintenance of the standards set by the State.[72] The City of Chicago, the largest municipality in the District, also has laws regulating harbor water quality and the quality of wastewater sent through the City's sewer system to the Metropolitan Sanitary District treatment plant. The City monitors effluent quality throughout its own system to ensure maintenance of effluent quality before the effluent reaches the treatment plant.[73]

It is possible that the State will set up a series of water quality regions, as in California.[74] These regions are composed of adjacent watersheds. Water quality control practices vary from region to region to match the specific hydrologic system in each region. Every state must identify the problem areas for water pollution control as described in Section 208 of the Federal Water Pollution Control Act Amendments of 1972. Although most states identify only problem areas, in California the entire state is divided into regions.

The Environmental Protection Agency has a stated policy to protect the nation's wetlands.[75] Wetlands, including swamps, marshes, bogs, and other low-lying areas, which are covered by non-flood waters during some part of the year, support unique ecosystems of major importance. They serve not only as a habitat for a large variety of aquatic species and fur-bearing species, but also as a source of harvestable timber and as unique recreational areas. As part of the hydrologic system, wetlands moderate extremes in water flow, aid in the natural purification of water, and maintain and recharge groundwater.

In light of the importance of wetlands, the EPA has stated its policy

> "to give particular cognizance and consideration to any proposal that has the potential to damage wetlands, to recognize the irreplaceable value and man's dependence on them, to maintain an environment acceptable to society, and to preserve and protect them from damaging misuses.

"It shall be the Agency's (EPA) policy to minimize alternations in the quantity or quality of the natural flow of water that nourishes wetlands and to protect wetlands from adverse dredging or filling practices, solid waste management practices, siltation, or the addition of pesticides, salts, or toxic materials arising from nonpoint source wastes and through construction activities, and to prevent violation of applicable water quality standards from such environmental insults."[75]

Local laws affecting water use and pollution control will specify conditions for use of and connection with the municipal sewer system and sewage treatment plant, if locally operated. The municipal plant operations are subject to the state laws discussed above. It is possible that the city or county will have laws regarding construction practices that can cause accelerated erosion and sedimentation.

Certain laws exclusively protect plant and animal habitats or the animals themselves. The Federal Endangered Species Act[76] protects species that are threatened or endangered because of any of the following factors:

1. The present or threatened destruction, modification, or curtailment of its habitat or range;
2. Overutilization for commercial, sporting, scientific, or education purposes;
3. Disease or predation;
4. The inadequacy of existing regulatory mechanisms; or
5. Other natural or manmade factors affecting its continued existence.

The Department of the Interior Bureau of Sport Fisheries and Wildlife maintains a list of threatened and endangered species and publishes additions or deletions in the Federal Register. The list includes mammals, birds, reptiles, fish, and plants. The EIS should present a list of any threatened or endangered species whose habitat or range includes the airport. The probable impact of the airport project on these species should also be presented in the EIS.

4.3.2 Identification of Sources

During the construction of an airport or any part of an airport, there is a significant potential for water pollution and alteration of the local hydrologic cycles. Construction generally involves removal of vegetation, alteration of topography (including land slope and water courses), and the introduction of impervious surfaces. The removal of vegetation from an area results in an increase in the velocity of stormwater runoff, which decreases the amount of infiltration into the ground and increases the amount of soil carried to the stream. The rapid arrival of the runoff water at the stream after a storm may also cause downstream flooding. Alteration of the topgraphy, including filling in channels and flattening slopes, can also increase the velocity of the runoff by removing depression storage or increasing the grade. Impervious area introduced to the site by construction (runways, taxiways, aprons, rooftops) also increases the velocity of runoff water and lessens the amount of infiltration of water into the soil. The long-term effects will be discussed below under airport operations. During construction, however, the staging of the various sub-projects can change the runoff patterns.

The rapid removal of soil due to loss of vegetative cover and alterations to the topography results in two phenomena: accelerated erosion and sedimentation. Accelerated erosion (in excess of the natural rate) destroys stream banks and removes topsoil. The soil removed, called sediment, is then deposited downstream, where it can do harm to aquatic and plant life. The following construction activities are subject to high risk of erosion: clearing, earthwork, ditch construction, haul roads, culvert installation, channel changes, pier or abutment work in streams, temporary stream crossings, borrow pit operations, and hydraulic and mechanical dredging.[77]

From the start of a construction project, there are many sources of water pollution in addition to sedimentation. Following is a description of each activity likely to cause water pollution, in the order in which the activities occur during construction.[78] First are clearing, grubbing, and pest control. The removal of vegetation can increase erosion and resulting sediment loads on nearby streams. Pest control, particularly the use of sprays, introduces long-lived toxic chemicals into the water. The next process is rough grading, which includes the use of heavy construction equipment for earthmoving, excavation, and fill operations. The equipment itself is a source of water pollution with the potential of spilling or leaking diesel fuel, oil, and lubricants. Since vehicles are very heavy, severe compaction of clayey soils can occur. The compaction lowers the rates of water infiltration and soil aeration, and makes revegetation very difficult. The grading of soil done by the construction equipment exposes subsoils which are more easily transported by water and air. If drainage patterns are altered, flooding and erosion of stream banks can occur.

Construction of the facility is the next step. For airports, the facility consists of buildings, runways, and other paved surfaces. All of the solid wastes generated during this phase are potential water pollutants. Concrete operations can pollute water through washing spillage, and the waste of various materials such as cement, bituminous materials, and curing compounds. Stripping of surface soil, stream diversions, soil stockpiling and cofferdam construction are potential sources of water pollution. The access and haul roads, construction workers' campsites, and the pattern of traffic flow around the site contribute to erosion and pollution. The final stage of site restoration, including cleanup, final grading, tillage of compacted soils, and establishment of permanent vegetation, can also increase sediment loads if not done properly. The sanitary waste from on-site employees is also a potential water pollution problem during all phases of construction.

The operation of an airport entails two significant kinds of water-related environmental impacts. The first of these is the effect of potable water intake and the second is associated with the wastewater discharges. The large amounts of water drawn from groundwater, streams, or lakes can significantly affect water tables and local water quality if the intake water is drawn at a rate greater than the natural replenishment of the supply, especially for large airports. The amount of water that an airport will draw depends on the functions housed at the airport. A brief survey of currently operating airports shows a wide variance depending on the number of annual passengers (enplaned plus deplaned) and the extent of maintenance and overhaul facilities. The figures presented in Table 7 for average consumption per passenger are taken from specific airports and are not to be construed as standards. They are included for discussion purposes only. They represent order-of-magnitude estimates of average water use; for example, peak daily flows, which occur in the month of August, will be at least twice as high as the average daily flow in any month.

Table 7. Water Consumption Rates at Four Commercial Airports (1973)[79]
(NOT TO BE USED AS GUIDELINES)

Water Consumption (gallons/passenger)	Airport Size	
	Million Annual Passengers	Maintenance Base Included
7.9	4.1	No
42.9	11.8	Yes
14.3	11.8	No-terminals only
32	17.1	Yes
14.5	39	No

The trend shown by these figures is that larger airports, as measured by annual passengers, tend to consume more water per passenger than smaller airports. Several factors explain this. Larger airports tend to attract more visitors for each passenger who enplanes or deplanes at the airport. A large airport is more likely to have restaurants and hotels within the airport boundary. Passengers are likely to stay longer at a large airport waiting for connecting flights. Some large airports have extensive maintenance bases, equivalent to an industrial park, for internal and external maintenance of aircraft. These bases are significant water users, as noted by the exceptionally high per passenger water consumption values found at the two airports in Table 7 having "Yes" in the column headed "Maintenance Base Included." In fact, a comparison of the second and third entries in the table, reveals that up to 28.6 gallons of water per passenger can be used by a busy maintenance base.

However, water distribution system design cannot be based on these average annual figures. Considerations of pipe diameter must be based on peak and not average flows. Supplemental systems for contingencies, such as fire fighting, must also be accounted for in actual system design. For impact assessment purposes, however, these figures can provide order-of-magnitude estimates of average annual or daily use as a function of airport size. For planning purposes, current airport projects frequently report higher expected rates of use than those shown in Table 7. The proposal for the Dallas-Fort Worth Airport, for example, used 78.3 gallons/passenger for 18 million passengers per year as a design figure.[80] Of course, extensive water use for irrigation and air conditioning was allowed for due to the climate in Dallas. The figure is higher than the measured values in Table 7 for that reason and also to make the water distribution system more flexible to changing airport growth and passenger water usage rates.

The wastewater output of an airport is generated from both point and nonpoint sources. Sanitary wastewater and industrial wastewater are point source discharges, while impervious area runoff is considered a nonpoint source discharge. Using the categorization suggested in the U.S. EPA "Draft Development Document for Proposed Effluent Limitations, Guidelines and New Source Performance Standards for the Air Transportation Segment of the Transportation Industry,"[81] a summary of flow volumes by source and pollutant control parameters is presented in Table 8. All pollutants contained in the airport wastewater stream are either pollutant control parameters or secondary pollutants. The level of the pollutant control parameters indicates the quality of the effluent stream. Although other pollutants are likely to be present in the effluent, the level of the control parameters indicates the presence or absence of these secondary pollutants. For example, in the wastewater stream discharged by Aircraft Rebuilding and Overhaul activities, detergents are not selected as a control parameter because the physical-chemical treatment needed to remove oil and grease also removes detergents.

Aircraft ramp service consists of operations necessary to prepare an aircraft for flight and is performed outdoors near loading and unloading areas. The services include refueling, removal of sanitary and other wastes, replenishing water and other supplies, inspection and servicing prior to flight, and some minor maintenance. These services will be provided at most commercial (serving scheduled airlines) airports. Wastes that might pollute water come from spills and leaks. Some smaller commercial airports and most general aviation airports do not have facilities for removal of sanitary wastes from aircraft.

Table 8. Characteristics of Wastewater from Airport Activities (excluding runoff)

Water Pollution Source	Range of Daily Flow (million gallons) per day, mgd)	Pollutants (Control Parameters)
1) Aircraft Ramp Service	0.2-0.5 mgd	oil and grease suspended solids
2) Aircraft Rebuilding and Overhaul		
a) Engine Operations	0.15-0.45 mgd	pH, COD (chemical oxygen demand), BOD (biological), suspended phenols, cyanides, cadmium, chromium, copper, lead, nickel, zinc.
b) Airframe Operations	0.1-0.3 mgd	
3) Aircraft Maintenance		
a) Routine	0.001-0.002 mgd	oil and grease, suspended solids, pH
b) Washing	3,000-12,000 gallons per aircraft; 2-20 aircraft per week	oil and grease, suspended solids, pH
4) Ground Vehicle Service & Maintenance	0.001-0.002 mgd	oil and grease, suspended solids, pH
5) Fuel Storage Centers	Minimal	oil and grease, solids etc., are emitted if there is a fuel spill
6) Terminal and Auxiliary Facilities	7-20 gal/passenger [0.002-1.5 mgd]	(sanitary waste) BOD, suspended solids, total coliform

Aircraft rebuilding and overhaul activities are principal sources of industrial wastewater at airports housing such operations. Generally, the commercial airlines establish one or two home bases for all major aircraft maintenance at an originating/terminating airport, such as Miami International Airport or San Francisco International Airport. An overhaul base might completely dismantle, repair, and clean four aircraft engines a day. During engine operations, the parts are cleaned in strong detergents and necessary metal plating is done, generating large amounts of industrial pollution in the wastewater stream. Exterior and interior airframe operations include rebuilding and repairing airframe operating mechanisms and utility systems, reupholstering, painting, and general cleaning of the interior of the aircraft.

Aircraft maintenance is generally performed indoors in hangars. Routine maintenance includes changing hydraulic lines, wheels, or tires, spot painting, partial engine overhaul, and cleaning interiors. The extent of maintenance done at any particular airport depends on the facilities provided by the airlines. Aircraft washing is performed at most airports. Small aircraft used in general aviation are washed primarily with water and some detergent; strong solvents are likely to be used on large aircraft, although water is the primary cleaning agent. Detergents and whatever accumulates on the exterior of the aircraft are therefore the water pollutants. Additionally, in the winter in areas where the temperature goes below freezing, aircraft are sprayed with deicing compounds. The deicing compounds used for aircraft have glycol as a primary component. Glycol contributes to increases in the biological oxygen demand (BOD) of the effluent. Thus, the effluent treatment process must be altered to account for this pollutant load. Efforts are underway to determine the optimal treatment process.[82] Another possibility which becomes more attractive as prices rise, is to collect and recycle the deicer until it is too weak to be effective. The feasibility of this strategy is now being studied. Deicing of runways and vehicle access areas is accomplished through the use of salt, in the same way as for highways.[83]

Ground vehicle service and maintenance consists of all processes related to ground vehicles such as luggage carts and refueling trucks. Servicing for these vehicles is usually handled at the airport. Within the shop for servicing, solvents, oil, and grease are likely water contaminants. The vehicles can spill or leak oil, grease, fuel, and lubricants. Larger airports will have more of these vehicles; small general aviation airports would have very few such vehicles.

Fuel storage centers are remote from the other airport areas, but located on the airport property. The water pollution potential arises from the potential for leaks and spills. Underground tanks using pipe storage have the least probability of accidental spills and leaks. Trucks might also be used to transport the fuel and oil to the ramp service areas, increasing the potential for spills. Surface tanks are usually diked to contain any large spills that might occur.

The terminal and auxiliary facilities are sources of domestic-type wastewater. The amount generated depends on the number of passengers and visitors at the airport as well as on the other services provided, such as restaurants. This type of waste occurs at all airports.

Stormwater runoff, a nonpoint source of wastewater, comes from all areas of an airport. With the runoff comes any spilled oil, loose debris, leaked fuel, rubber tire deposits, and accidentally discharged chemicals that are on the impervious surfaces. Airborne pollution will also find its way into the runoff, especially particulate matter. The volume of runoff water generated by the airport is larger than the amount generated on the pre-airport land on account of the increase in impervious area. The velocity of the runoff water is also increased due to the removal of vegetative cover. These two factors combine and increase the potential for erosion and the resulting sedimentation. The flooding potential is also increased, proportional to the amount of impervious area added. The long-term effects of the additional impervious area created by a single airport are probably small. As one more step in paving over a significant portion of a watershed, however, the impacts are significant.

Ecological impacts of airports are primarily water related because most of the potential damage is related to alterations in the water quality or in the stream flow patterns. The primary impact of airport projects on the plant and animal ecosystems is the destruction of habitat. Very few instances of loss of habitat due to noise or air pollution have been observed, although alteration of the hydrologic system or of water quality may destroy habitats. Animals are not normally killed outright by any airport-related activity, except in the case of bird strikes. Plant life in any area may be obliterated if it creates a safety hazard, such as trees in a clear zone.

Once the airport is built and operating, it naturally preempts the habitat of wildlife where the runway and buildings are located. Beyond the buildings but within the airport property, minimal interference with wildlife habitat can be expected, with a few exceptions. Among these are that animals are actively discouraged for their own survival from approaching or crossing runways, and that species dependent on the pre-airport water quality will be forced to leave the area or die if the quality of runoff water is poor.

If an airport is to be constructed on or extended into a body of water, such as a lake, estuary or wetland, special precautions must be observed. The dredging and filling alone required to build the airport may have serious enough environmental consequences that the site should be abandoned. Such construction has long-term irreversible survival effects on aquatic species. An excellent discussion of the potential effects of an airport on bodies of water and the ecosystems dependent on them can be found in Airports and their Environment.[84] The Big Cypress Swamp Jetport Environmental Report[85] presents a similar discussion for the specific case of the South Florida ecosystem.

The other major potential impact of an airport project on the ecology is the impact on bird life. Migrating and resident bird populations can interfere with airport operations, and vice versa. Airport location and the major flight paths should be set with knowledge of bird habitats, especially feeding grounds. Efforts should be made not to have flight paths of aircraft crossing major bird flyways between nesting and feeding grounds, or along migratory routes. The placement of sanitary landfill on or near airport property is significant as landfills are potential feeding grounds if no other satisfactory area is available to the birds (further discussion in Sec. 4.4). An airport located near a wildlife refuge or bird sanctuary may have serious impacts on the animal population (e.g., condor sanctuary) or on the human population wishing to see these natural environments.

4.3.3 State-of-the-Art Assessment Techniques

4.3.3.1 Evaluation

Although there are techniques for predicting erosion and sedimentation losses[86] during construction, no discussion of these will be presented. The most effective means of minimizing the impact of construction practices is source control. That is, rather than predicting the soil loss due to various construction practices and then selecting one method of after-the-fact treatment of the water, construction practices may be changed so that few or no pollutants are released and stream flow is not altered. These techniques are discussed in Section 4.4.4: Abatement Strategies.

Prediction of potable water use is based upon engineering estimates, which are based upon information similar to that presented in Table 7. The impacts on the local hydrology of drawing water from a particular source are also determined by engineering analysis. With the aid of simulation models,[87] the size of the supply to be tapped, its sources for replenishment, and other drains on that supply are all taken into account in deciding whether to draw potable water from a particular supply. The decision as to where to draw water is not normally made by the airport. Generally, agreements must be negotiated with local municipalities, with the approval of the state, regarding the best supplier for water. Thus, this aspect of the airport's impact is likely to be analyzed by outside agencies who supply potable water, although a discussion of the impact must be presented in the environmental impact statement.

Point source discharges of wastewater are relatively easily controlled for quality and rate of discharge to the hydrologic system compared to non-point source discharges. In general, most relationships between ecology and hydrology are understood to the point that it is clear that source control is the preferred method for maintaining high water quality. Thus, no models describing the effects of pollutants on ecosystems are presented here.

The relevant modeling efforts are in the area of non-point source discharge. Both the quantity and quality aspects are modeled, although modeling of water quality is still in a developmental stage. Non-point source discharge is basically stormwater runoff. In an undisturbed area, rainwater is detained in several ways before reaching natural drainage detention storage on leaves, grasses, and small depressions, and infiltration into the ground. The natural channels for drainage have a limited capacity to transport water. Water flows in excess of that capacity cause overflow (flooding) or erosion of the banks due to increased flow velocity. Thus, the barriers that slow the runoff on its way to the channel are essential in maintaining the hydrologic system. Disruption in the hydrologic system has impact on the ecological systems it supports. Flooding can drown species residing near the stream banks or destroy their habitat. Erosion of the stream banks yields an increase in the sediment load. When deposited downstream this sediment can affect fish and their breeding grounds, and cut off the light that would have reached growth at the bottom of the stream bed.

Undeveloped areas covered with grass or trees are considered to be pervious; that is, a significant amount of rain (80-95%)* falling on the ground passes through the soil and slowly reaches the natural drainage channel underground. Pavement and buildings are impervious; most of the water (70-95%)* striking the surface runs off and approaches the drainage channel overland. In highly developed areas, most natural drainage channels have been paved over and replaced with manmade pipe drainage systems. The models currently available attempt to predict the effect of changes from the undeveloped or present situation on flow patterns. Typical input includes meteorological and topographical information, especially the split between pervious and impervious areas, and channel capacity. The models have as their purpose either planning, design, or control. Planning models are less detailed and aim to predict flow patterns due to the additional development. Models used in the design of collection systems allow descriptors of manmade collection systems to be entered as variables. Alternative systems can be tested for their ability to handle peak discharges and different patterns of rainfall intensity. There are also several mathematical models used in control and operation of water collection systems. They cannot be used in the planning stage since the collection system is considered fixed for this type of model. The model variables include decisions on where to shunt the

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*As per ASCE Recommended Runoff Coefficients.

flow to maximize pipe storage and to minimize the amount of untreated runoff reaching natural streams and lakes.

There are at least 100 models, available as computer programs, to simulate the effect of development on stormwater runoff quantity and quality.[88,89] In addition to being categorized by purpose (planning or design), they can also be classified by authorship: government-sponsored, university research, or proprietary to a consulting organization. The authorship is indicative of the general availability of a model. Government-sponsored models are easily available from the sponsoring agency, usually the U.S. EPA or the Army Corps of Engineers. University research models are available, but not easily adaptable to other computer system and often are experimental. The lag time in setting one up for a project would be significant and highly skilled programmers would be needed to make the transition from one system and data base to another. The proprietary models are available, but at cost. As a rule, the proprietary models are general enough to be easily adapted to a new project. The firm that supports the computer program most likely has access to facilities on which to run their model, eliminating problems of transfer to different computers.

For historical perspective, it should be noted that all of the detailed simulation models are recent efforts made possible by the computer. Previous hand models, now considered inadequate, could predict only peak flows, while the computer models produce complete flow records (hydrographs) for various types of storms and combinations of storms. The primary hand model is called the Rational Method. The essence of the model is the equation

$$C = c \cdot i \cdot A ,$$

where

Q = Peak discharge in cubic feet per second

c = Coefficient of runoff

i = Average rainfall intensity in inches/hour

A = Drainage area.

The only parameter that is difficult to determine is c, the runoff coefficient. Tables relating the percent of paved area, general soil types, and average slope to the runoff coefficient were developed over time. Although this method is much criticized, it has been and will continue to be widely used, especially when only peak flows are needed for design and the watershed is fairly small (5 acres or less).

The computer simulation models available can be distinguished by whether water quality analysis is included with the quantity analysis. At this stage in the development of runoff models, however, quality modeling is experimental. Thus, the option will be noted in the description of available models, but it is not considered a significant factor in the overall usefulness of the model. Quantity modeling has several components, handled differently by each model:

1. Size and number of catchments;
2. Single design storm or multi-event simulation;
3. Land use;
4. Overland flow;
5. Depression storage;
6. Infiltration;
7. Pipe network.

The size of catchment allowed varies from 5 acres up to 100 sq miles. There is generally a limit on the number of subcatchments, which corresponds with the maximum area to be modeled. That is, if very large basins or catchments can be modeled, then the maximum number of subcatchments will be large. The Cincinnati Urban Runoff Model, for example, expects uniformly pervious or impervious subcatchments, so each one is small and there are very many allowed.[89]

A model's usefulness is determined by whether it accepts design storm input data and produces one flow pattern, or accepts historical rainfall-runoff data to produce continuous results. It is more desirable for a planning model to produce continuous output, while design calls for a worst case (or design storm) analysis. A design storm is characterized by its intensity and duration, and identified by the frequency that such a storm is likely to occur. A 10-year storm, likely to occur once in ten years, is the accepted design storm for design of regional stormwater collection systems. The way in which land uses are recognized affects the ease of use of the model. The Cincinnati model mentioned above specifies land use only as pervious or impervious. The STORM model by the Corps of Engineers, on the other hand, has five categories of land use that can occur in each watershed. Each land use is allowed a unique value of "% impervious" and the existence of gutters and the frequency of street sweeping is also set for each use.[90]

Overland flow is usually simulated by using Manning's equation. Empirical expressions relating outflow depth, detention storage, and detention storage at equilibrium may be used in conjunction with Manning's equation, as in the Cincinnati model. Depression storage can be handled in several ways. It can be set up that a certain fraction of the area has no depression storage so that immediate runoff can occur; the remaining areas provide runoff only as the depression storage is filled up. More sophisticated models deplete depression storage by infiltration. The infiltration process is generally modeled with Horton's equation. In some cases only the rainfall, without depression storage, is considered a source for infiltration. If a model can accept a pipe network, then pipe storage and flow routing can also be accounted for. This option is important for modeling urban areas whose primary drainage is through pipes.

A problem with stormwater runoff models in general is that none have been validated. Validation includes many tests of the model results against observed conditions, using standard statistical measures of fit to judge the correctness and reliability of the model as a simulator of observed events. Until thorough validations become available, the user can obtain a rough measure of the reliability of a particular model for simulating flows in a particular watershed by simulating an observed event or series of events (storms) occurring in that watershed. If the results are reasonably similar and conservative when in error, the reviewer can be fairly confident of the model's predictions.

4.3.3.2 Application

There are many useful models that simulate urban stormwater runoff. There is no agreement in the literature as to which among them are the most useful and accurate. In view of this situation, a review of several representative models is presented in Appendix D to give the reviewer an idea of what information a stormwater runoff model can be expected to provide. Because of the developmental state of the art of stormwater runoff modeling, definitive guidance on when to use a large-scale computer simulation solely because of the airport project cannot be provided. At the least, the airport project, if it involves the addition of impervious surface with buildings or runways, should be accounted for in any regional stormwater management planning.

4.3.4 Abatement Strategies

Strategies for the abatement of the impacts of construction on water quality and hydrologic cycles are extremely effective. Ensuring that these techniques are used is critical: "Water pollution resulting from sediment and other pollutants (including stormwater) generated from all types of construction activity can be minimized by the timely application of structural and soil stabilization measures...Individual or institutional planning initiatives that culminate in a plan for water pollution abatement [must begin] before construction actually begins."[91] Any techniques that the sponsoring agency knows will be needed during the construction should be listed in the specifications so that contractors' bids will reflect the use of necessary abatement strategies. The contract should detail specific strategies when possible, and dictate the use of appropriate pollution control techniques for unexpected situations. Inclusion of these provisions in the contract, plus monitoring throughout the period of construction to verify that the terms of the contract are being met, can eliminate nearly all construction impacts on water quality and quantity.

A complete discussion of the full range of erosion control techniques and the appropriate timing during the construction period can be found in several EPA documents.[78,92,93] The FAA has published an advisory circular itemizing erosion and sediment control measures.[94] An overview of the techniques and strategies is presented here, drawing on these documents. The majority of the strategies are aimed at erosion control. During the early stages of the project, when grubbing, clearing, and pest control activities occur, the control options include minimizing the amount of vegetation removed, removing vegetation as needed rather than all at once, converting trees removed to wood chips for use as mulch to protect exposed soil, and limiting the use of general purpose pest controls by replacing them with specific pesticides while relying on natural predator-prey relationships as much as possible. During rough grading, specific limits to the amount of soil that can be exposed at any one time should be adhered to. An often suggested limit is 175,000 sq ft. In some areas this figure may be too high; therefore engineering judgment is required to distinguish special cases. The routes of the heavy equipment should be determined so as to minimize pollution by prohibiting the fording of streams and building temporary bridges where frequent crossings must be made. During facility construction, seeding and planting on exposed areas should take place as soon as possible. Solid wastes should be stored in closed containers and removed from the site. The problem of sanitary wastes can be solved through the use of portable chemical toilets, which can be discharged to the municipal sewer system.

Throughout the project, consideration must be made for the routing of water within the site. Since the slope of the land and the barriers to overland flow are being changed during grading and construction, drainage patterns are also altered. Damage on the site and downstream from the site can occur if water routing is not carefully planned. Diversion dikes and retention basins installed after rough grading can lessen erosion and the amount of sediment carried downstream. The retention basin must be maintained, however, and the trapped sediment removed when the basin is half full. Many slope and stabilization devices are available, including fiber mats, woven plastic filter cloths, gravel, organic fiber and wood chip mulches, quick-growing grasses, sod, bituminous spray, filter berms, chemical soil binders, and flexible downdrains.

Final landscaping and revegetation must be designed to mitigate long-term effects of the disruption to the natural system brought about by the construction of the airport. Turfed areas should be maintained where possible.

During the operation of the airport, there are many strategies for minimizing the impacts on water systems. The potable water draw can be made from the source most able to accommodate the airport, according to regional availability of water. Sanitary wastewater must be subjected to treatment in either an airport- or municipally-operated treatment plant, operating according to standards as discussed in Section 4.3.1: Federal, State, and Local Standards. Industrial wastewater streams are pretreated at the airport. Treatment methods for airport industrial wastewater, including sample treatment plant layout, are presented in an EPA document[95] and an FAA advisory circular on industrial waste treatment.[96]

Stormwater runoff quality is not yet regulated, although government officials are aware of its contribution to water pollution, as well as the difficulty of treating the runoff at a reasonable cost. Although a stormwater collection and treatment system is not currently required for airports, "It would seem prudent, however, in the planning of airport expansion or the construction of new airports, that airfield drainage systems have the capability, when required, of channeling certain portions of all airport runoff to one location for waste treatment processing."[97] An economical strategy for this is one in use at some airports already. Runoff water is directed toward a retention pond before drainage off the airport, where oil products can be removed for salvage using skimmers or gravity separators.

The principal strategy for recognizing ecological impacts is to inventory plant and animal species in the airport environs, along with any special interdependencies among species, and geographic features necessary to sustain these species. Assuming that water quality standards are met and the local hydrology is not severly altered, methods to minimize the impacts on the plant and animal ecosystems include consideration of the habits of species involved during the location of airport buildings, runways, access roads, and major flight paths.

4.4 SOLID WASTE IMPACT

4.4.1 Federal, State, and Local Standards

Federal responsibilities for and involvement with solid waste impacts stem from the Solid Waste Disposal Act.[98]

1. Encourage enactment of improved state and local solid waste management laws;

2. Research and development of new technologies and management techniques;

3. Provide technical assistance to state and local governments;

4. Aid in planning efforts of state and local governments.

The Office of Solid Waste Management Programs within the U.S. Environmental Protection Agency assumes these responsibilities.

State laws vary considerably in scope. A survey of state solid waste laws[99] shows them to be fragmented and uneven in coverage. They range from requiring permits for landfills to setting up comprehensive, coordinated statewide solid waste disposal and treatment programs.

Most responsibility for solid waste handling lies with the local governments. The local laws vary even more than the state laws, as summarized in a U.S. EPA survey of selected local laws.[100] These laws tend to be very specific to local problems in a nonsystematic way. The topics that are likely to be covered include definitions, container types, and collection frequency for certain types of land uses (e.g., residential, commercial). Requirements for planning may sometimes be included. Permits are nearly always required for collection of solid waste and for disposal or treatment.

4.4.2 Identification of Sources

The kinds of solid wastes generated during the construction and operation phases of an airport vary in amount, composition, and applicable abatement strategies. The amount of solid waste generated during the construction of an airport, or any extension, varies, depending on the size of the airport and the local topography. The potential sources during construction are earthmoving operations, demolition, construction processes, and employees. The amount of solid waste resulting from earthmoving operations, including grading and excavation, is highly dependent on the particular project. It will be composed of topsoil, clay, rock, and any type of soil water, hangars, and maintenance bases must also be removed from the airport. These are collected separately from other solid wastes.

4.4.3 State-of-the-Art Assessment Techniques and Abatement Strategies

All solid wastes generated at an airport are included in this discussion, except for sewage sludge. This is defined to be part of the wastewater system and is discussed under Section 4.3

4.4.3.1 Transporting

The transport phase of solid waste management includes both in-house collection and transport to a final disposal site. There are four constraints on the methodologies used for this phase of treatment: cost, safety, health, and aesthetics. Each of the these constraints limits the methods that can be used.

1. Cost: The method selected for collection and transport must be economical to the tenants of the airport.

2. Safety: The method selected for transport must not interfere with aircraft operations. If vehicles are used, for example, they must be excluded from runways, taxiways, and aprons. Loose debris in the runway area may be ingested by jets, causing damage to the engines during takeoff.[104]

3. Health: Wastes that are potential health hazards must be stored properly and removed often. This category includes food wastes and any toxic industrial wastes. Food wastes must be removed at least once a day. Oil wastes must be properly stored to minimize the possibility of explosion or fire.

4. Aesthetics: The collection containers must be attractive and of a type that would prevent wastes from being tossed about by the wind, stray animals or careless handling. This is of concern primarily with paper wastes.

The techniques currently in use include containers plus truck transport; wet pipe transport plus truck transport; and dry pipe transport plus truck transport, if necessary. The first method is most common.

Various-sized containers are placed around the airport. The trucks then make regular pickups from these containers and proceed directly to the disposal site. Variations in this method include the use of small trucks that pull wheeled containers to the disposal site or an intermediate transfer point, and the use of containers that fit onto lifters on the front of the truck and are then dumped into the truck for compacting and transport to the disposal site. The solid wastes might also be processed before transport to the disposal site. The methods used include stationary compaction, incineration, shredding, and high compression baling. All are used to reduce the bulk of the waste. Incineration must be carried out carefully, so as not to contribute to air pollution because of incomplete combustion. Separating out noncombustibles, shredding bulky wastes, using more than one combustion chamber, and electrostatic precipitators are techniques that help to minimize air pollutants from the incinerator.

Wet pipe transport requires large-sized garbage disposal units at the collection points. The slurry is piped to a central point, where water is removed. The sludge remaining is then trucked to a final disposal site. The method is suitable for sources that are clustered together, such as the terminal buildings.

Dry pipe transport makes use of vacuum pressure to move the unprocessed solid wastes to a central point, for either transfer to trucks or final disposal. This is a relatively new methodology. The additional expense of laying large pipes underneath existing pavement limits the use of this system to new airports. It is capable of moving up to 30 tons per day of solid waste, which is adequate for most airports at present waste-generation levels.

Waste materials that are recyclable must be collected and transported separately from other solid wastes.

4.4.3.2 Disposing

Solid wastes generated at an airport during its construction are dealt with in several ways. Earthmoving operations can be kept to a minimum. Topsoil is stockpiled for use during the final stages of construction, such as landscaping. The proper handling of excavated soil is present locally, plus any trees or shrubs cleared before construction. Demolition can produce a large amount of solid wastes, such as broken up runway pavement, bricks, glass, concrete, electric wiring, metal fixtures, wooden supports, plastic, and textiles. The processes used in construction, such as asphalting, mixing and laying concrete, applying sealers, painting, bricklaying, and wiring, produce a variety of solid wastes. Examples of the kinds of wastes expected are plastic bags, paper bags, wooden crates, plastic and wooden forms for concrete, metal cans, waste mortar, concrete and asphalt, construction wood scraps, metal fasteners, and copper wire. The construction employees are the final source of solid waste, although the amount generated is much less than for the above three sources. Paper and food wastes are the principal types of solid waste to be expected.

The volume of solid waste generated at an airport during its operation varies with the kinds of facilities provided at the airport. An aircraft maintenance and overhaul base will generate a significant addition to the solid waste load, as will restaurants or extensive air cargo handling. In one study a variation in per passenger solid waste operation from 0.6 to 2.2 lbs was found for similar size airports (daily passengers) having different restaurant facilities.[101] The addition of restuarant facilities adds not only the restaurant-generated solid waste related to airplane passengers, but also additional solid waste due to the greater number of visitors at the airport having a restaurant.

In general, the areas of an airport that produce solid waste are:[102]

1. Passenger terminals;
2. Aircraft service areas (including flight kitchens and hangars);
3. Air cargo areas;
4. Aircraft maintenance base.

Other airport land uses, such as restaurants and hotels, are not included here, since the solid wastes generated by them are not necessarily handled with those of the rest of the airport. These two uses, if present at an airport and included in the airport's transport and disposal system, however, contribute a significant portion of the total waste. One large airport with heavy passenger and cargo traffic finds that 20% of the total waste load is generated by the hotel and restaurants.[103] Industries locating on the airport property are normally not included in the airport's solid waste management planning.

The amounts of solid waste generated by each source, according to a study done at San Francisco International Airport in 1972,[102] are as follows:

(NOT TO BE USED AS GUIDELINES)

1) Passenger terminals	:	0.53 lb/passenger
2) Aircraft service centers	:	1.02 lb/passenger
3) Air cargo area	:	7.10 lb/ton of cargo
4) Aircraft maintenance base	:	2.19 lb/employee/day

These figures are based on data from only one large airport, with approximately 15 million passengers per year (about 41,000 per day). Two other studies found similar results for different-sized airports.[101,103]

Note that the units for each source are different. Each rate is related to an activity that is characteristic of the source. Alternatively, all solid waste could be attributed to passenger activity, but the results would not be as useful as not all of the four activities listed above are included at all airports. If all of them are included at an airport, the ratio of total solid waste to passengers would be between 3 and 5 lb/passenger. With only the first two activities, this ratio would be 0.6-1.5 lb/passenger. The rates of generation are applicable to all air carrier airports (airports having scheduled commercial airline flights). They are likely to be too high for general aviation airports (airports serving private and business flights), because there is no airplane passenger food service and the terminal facilities are smaller.

The composition of the solid waste also varies with airport size and the type of facilities. In general, the main components are paper products, food wastes, and plastics, which account for about 80% by volume. The relative proportions of wood, glass and ceramics, dirt and rocks, and metals vary with the amount of air freight tonnage and the nature of the maintenance base. They account for 15-18% of the total. The remainder are miscellaneous wastes, including leather, rubber, and textiles. Oil wastes collected from runoff crucial in minimizing water pollution in the form of sediment. (Methods for water pollution control are discussed in Sec. 4.3: Water and Wastewater Impact.) Demolition materials must be stockpiled, protected, and then removed from the site if not usable as fill on the site. Solid wastes from other sources must be contained and then removed and disposed of according to local law. Specific conservation practices, such as using cleared trees as a wood chip mulch for erosion control or stockpiling topsoil, must be written into the construction contract. In general, the strategy for minimizing solid waste impacts during construction is to write specific requirements for control techniques into the contract.

The most common method of disposal of solid waste is the landfill. A properly run landfill poses no health hazards. The airport operator must dump the solid wastes into a properly operated landfill, according to local law, or contract it out to a licensed scavenger. The airport has another involvement with solid waste disposal, however. Any landfill is likely, under certain conditions, to attract birds. If the airport operates a landfill on its property, or one is operated adjacent to the airport, there can be a hazard from bird strikes. This hazard can be minimized through appropriate placement of the landfill with respect to both aircraft flight paths and habitats of birds and through proper operation of the landfill.

Much work is currently being done in the field of solid waste management. The Office of Solid Waste Management Programs of the U.S. Environmental Protection Agency publishes a bibliography of solid waste information materials, which cites recent journal articles and project reports.[105] This information will be helpful to the EIS reviewer in remaining abreast of state-of-the-art techniques in solid waste management.

4.5 LAND USE IMPACT

4.5.1 Overview

All of the impacts of an airport project can be related via the land use impact. Adjacent land uses will change in direct response to the presence of the airport. The impact of an airport project on land use is included in both the primary and the secondary impacts of airport operation. The primary impact reflects the incompatibility of certain land uses with the airport. Height limitations exist on structures within the clear zones; industries whose operation would interfere with communication between the control tower and aircraft are not allowed near the airport. These controls imposed on the surrounding area are necessary for the safety of aircraft operations. The presence of the airport engenders serious impacts in the course of its operation on land uses whose locations near the airport are not out of a need to use the airport. That is, certain businesses and industries find it beneficial to locate near an airport in order to minimize ground transportation time and cost to the airport. However, large tracts of residential land uses are often airport neighbors. These incompatible uses in some instances preceded airport development, or were attracted to that area because of the improved ground transportation provided to serve the airport. Of course, a certain percentage are attracted to the airport area to be close to the jobs available at an airport. A conflict arises out of this situation. To provide air transportation service considered by some to be economically essential to an urban area, many non-users, who feel no direct benefits of the airport, are subjected to the impacts of the airport, including increased air pollution levels, noise levels, water pollution levels and impervious area runoff. The equitable solution is not clear, because both the airport and its neighbors have valid claim to their uses of the land.

Two approaches can be taken in ameliorating this situation: to lessen the amount of pollution (air, noise, water) at the source through operational and technological means; or, to disallow use, by sensitive activities, of land subject to a high degree of exposure to the emitted pollutants. Both approaches are being taken in the United States. Federal Aviation Administration regulations are directed at the first method. Quieter, cleaner engines are specified for the next generation of aircraft, along with operational guidelines aimed at minimizing exposure to noise and air pollution during landings and take-offs. Efforts utilizing the latter approach, land use control in the airport area, are more diffuse and less effective than the technological solutions. Since, at this time, there appear to be limitations on how clean and how quiet an airplane can be, land use control strategies will have to be implemented if we are to maintain air transportation as a viable mode. Currently, the only effective, though negative, control at the national level is the lack of availability of FHA mortgage funds in areas subject to high levels of noise. Other techniques must be applied locally, on a case-by-case basis. A complete discussion of available techniques, including the problems of implementing such methods, follows.

These land use control strategies are aimed at reducing primary impacts of airport operations. A complete control effort can also go a long way toward eliminating secondary impacts of an airport. Airports tend to attract development in the surrounding area for various reasons: access to air transportation of persons and goods; access to airport-related jobs; improved ground transportation services. This urbanization, which often follows airport installations, can generate severe impacts on pre-existing uses and overload the infrastructure of adjacent municipalities. The secondary impacts are difficult to quantify, however, since it is nearly impossible to determine exactly what portion of the growth would come regardless of the airport's presence and what portion is directly attributable to the airport's presence.

4.5.2 Federal, State, and Local Standards

The Airport and Airway Development Act of 1970 requires that action be taken to restrict land use near an airport to compatible activities.[106] The guidelines set forth by the Council on Environmental Quality for environmental impact statements also require that the project be consistent with plans and goals adopted by the community affected by the airport project.[107]

Although federal regulations specifically spell out the fact that land use planning must be considered throughout an airport project, the fact remains that land use planning, to date, is scattered, disorganized, and in many cases, powerless. On the federal level, no formal land use planning exists although bills have been brought before Congress in recent years to begin federal land use planning. State land use plans, for the most part, remain in the same tentative condition as their federal counterparts. Although most cities and local governments have land use plans, their effectiveness is questionable.

Therefore, rather than the EIS reviewer searching for standards, certain action should be taken. If the area in which the airport project is located has any land use plans, attempts should be made to incorporate the airport and adjacent land uses into the plans in a compatible manner. Basically, this consists of satisfying the goals of the communities surrounding the airport projects. If there are no land use plans, the area surrounding the airport project should be developed in such a manner as to have uses compatible with the airport. This may be satisfied by incorporating strategies discussed in this chapter for changing current land use or developing vacant land to be compatible with the airport project. The EIS reviewer should also be aware of the Environmental Protection Agency policy statement when considering the land use impacts of an airport project.[108]

4.5.3 Effect of Airport Project on Adjacent Land Use

The problems of compatibility between the airport and its surrounding land uses are a result of the absolute size of the airport, the number and variety of political districts adjacent to and affected by the airport, and the noise generated by the aircraft. Expansion of the airport system is extremely difficult today due to the central location of the older airports and the lack of available, acceptable land for new airport locations, yet the demand exists for additional airport capacity. A study of 21 of the largest metropolitan areas in the United States statistically shows the positive relationship between urban growth and the provision of air transportation services.[109] With the urban population still on the rise, this demand is expected to continue into the future.

An airport project normally generates far-reaching economic effects on the surrounding communities.[110] The direct effects include the jobs and associated payroll created by the airport on the site and also at airport-associated offices at other locations. The indirect economic effects include:

1. Purchase of local services and goods by air transport and related services;

2. Passenger activities including taxis, travel arrangements, and business generated by conventions;

3. Multiplier effects, including business generated by the spending of wages resulting from the above activities.

Finally, other external economic effects that are difficult to quantify include:

1. Market access;
2. Network benefits;
3. Regional growth benefits.

The induced development generated by an airport affects nearly every type of land use known. This includes private commercial enterprises, industrial uses, and urban development, including residential commercial, recreational, and institutional uses. This development in turn puts a demand on the water supply, generates solid wastes and air and noise pollution, and creates traffic along with congestion. The demand on natural resources and the generation of pollutants are secondary effects of the airport development.

One of the primary factors considered when determining whether a particular type of land use is compatible or incompatible adjacent to an airport is the noise exposure. In the report "Airports and Their Environment," a table lists land uses that may be anticipated at an airport.[111] The list also includes an appropriate noise exposure value (in NEF; see Section 4.2) relative to each type of land use. Another report prepared for the Federal Aviation Administration, entitled "Compatible Land Use Planning On and Around Airports,"[112] is recommended to the reviewer. Rather than basing the compatibility on noise levels alone, this report includes safety in terms of hazards involved in the operation of aircraft near the airport.

Basically, the report for FAA concludes that with the exception of open air assemblies, residential, and certain types of institutional land uses, most land uses are compatible with the noise levels generated and the safety considerations required by an airport. The report states that housing may be made acceptable in most noise-affected areas through soundproofing. In residential areas, even soundproofing would not lessen the effects of noise on outdoor activities. Considering the safety aspects, highway locations should not be immediately adjacent to airports due to the distractions created by the aircraft. Also, electric plants, power lines, gas and oil facilities, smoke-producing trash dumps and industries, and certain natural and agricultural uses that may attract birds should be avoided due to the hazards to aircraft operations.

In the report, ratings are given to a variety of land uses according to their location relative to the airport.[113] Each of the land uses within each category is rated according to its compatibility at various locations at or near the airport.

4.5.4 State-of-the-Art Prediction Models

As stated in the previous section, an airport project has tremendous, far-reaching effects on the adjacent land uses. The relationships between the airport and adjacent area are extremely complex, making it difficult to predict the final development pattern adjacent to the airport years after the project has been completed. Although a large number of land use models exist, few have the capacity for application to an airport project. In general, predictive land use modeling is in a developmental stage.

E. L. Cripps and D. A. S. Foot applied the Lowry Model to the Third London Airport in 1970.[114] In the study, the application of the Lowry Model is described in a comparative study of the urbanization effects on the outer metropolitan subregion of locating the Third London Airport at two proposed sites. The article focused on the description of the impact on spatial structures in the subregion, in terms of activity change and inter-urban journeys. The model was used in a single application (non-iterative) for the prediction of growth in the subregion without the airport, and then with the inclusion of the airport at two alternate locations. Growth without the airport was measured by basic and service employment changes, population changes, and inter-urban flow changes in the prediction year (1996). The same changes were noted for the two alternative locations of the airport.

Another land use model was developed by CONSAD Research Corporation for the FAA to assist in planning the land use adjacent to airports or proposed airport sites.[115] The objective of the model is to enhance the identification of alternative, feasible, and compatible land use configurations in areas around airports. The model considers the following dimensions:

1. Physical characteristics of area;
2. Demographic characteristics of population in area;

If an airport is to be expanded in the future, fee title may be used to buy adjacent, noise-sensitive land that can be leased in the interim.

Eminent domain, or condemnation, is the right of a sovereign government to take private land without the owner's permission for public use, along with the provision of "just compensation" to the owner. This is useful for the conversion of incompatible uses to compatible land uses. It has been used in the past to acquire airport property and adjacent property for the purpose of putting height and obstruction easements on the property. Avigation easements grant the right to the airport operator to fly over designated land, including the effects generated by the aircraft operation (noise, air pollution, etc.). This strategy is useful in providing additional land at the end of runway extensions.

Another technique for controlling land use is property regulations. Within this group, the police power gives local jurisdictions the authority to issue zoning regulations. Building and housing codes offer a solution for the structural compatibilities for new and existing housing (including soundproofing). Tax reductions may be used to attract noise compatible land uses to the areas adjacent to airports. They can also be used to compensate the current owners of noncompatible land uses.

The final technique available is property conversion. This may be in the form of government-funded conversion, such as urban renewal, or it may be privately funded. This particular technique was tested in a Department of Transportation study.[117] The study included Los Angeles International Airport, Miami International Airport, Long Island MacArthur Airport, and Dallas-Fort Worth Regional Airport. The redevelopment of incompatible land use was found to be an effective solution to airport noise, but also expensive and potentially disruptive. It appears to be unacceptable to large areas, but it may be useful in small, heavily impacted areas where other abatement procedures are ineffective. In most cases, this technique required large subsidies to be effective.

The study also tested the effectiveness of pre-emption of vacant land and the use of zoning and land use codes. Pre-emption was found to be useful in preventing future incompatible land use problems. The use of pre-emption for buffer areas worked well for new airports and smaller airports in less densely populated areas. It can be achieved by purchase and resale with restrictive convenants. Zoning and land use codes were found to be largely ineffective. Stronger zoning and building codes that are strictly enforced over the entire airport impacted area are needed to have lasting effects for conversion and pre-emption programs. Present zoning fails to be effective for the following reasons:[118]

1. Not retroactive;
2. Municipalities often ineffective;
3. Mixed jurisdictions, resulting in confused authority;
4. Poor zoning.

Overall, the abatement strategies give the developers of the airport project techniques to minimize land use impacts through the development of compatible land uses. The EIS reviewers will find the evaluation of these techniques useful in determining the effectiveness of a particular abatement strategy for a given airport project.

4.6 HAZARDOUS MATERIALS IMPACT

4.6.1 Federal, State, and Local Standards

Part 103 of the Federal Aviation Regulations identifies allowable hazardous materials for both passenger-carrying and cargo-only aircraft.[119] These materials are described in great detail relative to packaging, marking, and labeling requirements in Title 49 of the Department of Transportation's Code of Federal Regulations.[120]

The Environmental Protection Agency has published standards for national emissions of hazardous air pollutants.[121] Up to now these standards have addressed only beryllium, mercury, and asbestos.

The Federal Insecticide, Fungicide, and Rodenticide Act, as amended (86 Stat. 995), which makes it unlawful for any person to use a pesticide that is not registered with the Administrator of the Environmental Protection Agency or to use a registered pesticide in a manner inconsistent with its labeling, applies to all federal and state agencies. Thus, the use of pesticides in any proposed federal program must be in accord with all applicable provisions of the Act.

3. Existing enplanement pattern and level of support services (transportation, utilities, etc.) in vicinity of airport.

The model's development and operation is keyed to the geographic distribution of NEF levels. Land use activities identified for each parcel are evaluated by the direct benefit and costs of two alternatives. The first is in insulation of the activity against noise generated by the airport operation. The second is the relocation of the incompatible land use. The model then identifies suitable sites for activities that require relocation. From this, the model estimates the socioeconomic impact as a sum of alternatives adopted.

The area in the vicinity of the airport is then screened to find land use/aircraft generated noise incompatibilities. The area is examined to determine compatible land uses as follows:

1. Land use activities must be compatible with other activities in the area;

2. Land use activities must be compatible with transportation and utility-support structure existing in the area;

3. Land use activities must be compatible with existing and predicted noise levels in area.

With this completed, the model enumerates incompatibilities by acres of land. These are then analyzed by alternative remedial action programs to determine the total costs of incompatible uses.

The model yields the level of incompatibilities, the costs of remedial actions to resolve the incompatibilities, and the identification of feasible activities in the area. The model is set up to operate on an area 24 miles on a side. The exact input and output may be found in the text.[116]

The model has been assessed according to its implementation feasibility at 14 airports.[116] The large, commercial airports have mixed opinions of the model. For the most part, these airports do not possess the required data. Also, they lack personnel and computer capabilities, thereby requiring outside assistance. The medium-sized airports, on the other hand, appear to provide the best opportunity for the application of the model. Both the airport operation officials and the regional planning officials perceive a need for this type of planning instrument. Finally, the prospect for application of the model to small, general aviation airports appears small and they normally have minimal noise problems.

4.5.5 Abatement Strategies

To minimize the land use impacts generated by an airport project, a number of strategies may be incorporated to create compatible land uses adjacent to the airport. One method that has found application in many instances is land use planning in the airport environs. Basically, the process includes the following steps:

1. Delineate noise and hazard zones (and any other zones that are used in defining the compatibility of land uses);
2. Catalogue existing land uses and socio-economic characteristics;
3. Project future land uses and socioeconomic characteristics;
4. Determine economic impact and induced development;
5. Identify noise- and hazard- (and any other categories defined in 1) compatible development;
6. Identify incompatible land uses;
7. Develop alternative land use plans;
8. Identify tentative land control techniques;
9. Evaluate plans and strategies.

Within the land use planning process, a number of techniques exist for controlling land use. The first technique is property acquisition. This consists of fee title, eminent domain, and easements. Fee title is the outright purchase of land in noise- and hazard-sensitive areas. A home on this land may be sold back at a later date with some type of an "aviation" easement. The main problem with fee title is not only the expense in purchasing but also the loss of future taxes due to the removal of the land from the tax rolls.

The above statement should be included in the EPA response to those impact statements that are of a general nature and that state only appropriate insecticides, herbicides, etc., will be used. It should not be necessary in those statements in which specific pesticide formulations, identified by EPA registration numbers or descriptive chemical names are used.

4.6.2 Identification of Sources and Groups of People Exposed to Hazardous Materials

The total number of hazardous materials as defined by the Department of Transportation is on the order of 1200. A complete list of hazardous materials may be found in Title 49 of the Code of Federal Regulations.[120] Part 103 of the Transportation of Dangerous Articles and Magnetized Materials of the Federal Aviation Regulations specifies which types of hazardous materials are allowed to be carried on passenger-carrying and cargo-only aircraft.[119] Part 103 also specifies the packaging, marking, and labeling requirements, plus the maximum allowable quantities, for each type of hazardous material.

As specified by the Hazardous Materials Control Act of 1970, the Secretary of Transportation shall prepare and submit to the president for transmittal to the Congress on or before May 1 of each year a comprehensive report on the transportation of hazardous materials during the preceding calendar year. The report contains information on technology, research, and other efforts, accidents and casualty reports, regulation development, summary of reasons for waivers, evaluation of degree of compliance, and a summary of outstanding problems. The outstanding problem in 1973 for the transport of hazardous materials by air was the low level of knowledge of federal regulations on the part of both shippers and carriers.[122] To improve this situation, FAA required aircraft operators to train their personnel in the air carriage of hazardous materials by December 6, 1973. Also, FAA, in conjunction with the Office of Hazardous Materials, has conducted 13 seminars throughout the country to educate the shippers.

In 1974, an investigation was conducted to evaluate the FAA hazardous materials program.[123] Two major conclusions were drawn from the report:

1. At least 90% of the hazardous materials shipments examined by the evaluation team and found to be in noncompliance with FAR 103 were also in noncompliance with shipping regulations applicable

to other modes of transportation (truck, rail, etc.), which brought these shipments to the air carrier or freight forwarder dock.

2. The majority of problems in hazardous materials stem from noncompliance by shippers in packaging, marking, labeling, and documenting hazardous materials shipments. Regulations governing these subjects are adequate.

It appears from this study that the problems relate to the enforcement of hazardous materials regulations.

One hazardous material that has received special attention is radioactive material. A report entitled "Radiation Dose to Population (Crew and Passengers) Resulting from the Transportation of Radioactive Material by Passenger Aircraft in the United States" was published by the Atomic Energy Commission in 1974.[124] Radioactive exposures to passengers and crew members in aircraft carrying packages of radioactive material are controlled by regulations that limit the radiation dose outside each package and the number and positioning of such packages as loaded on a given type of aircraft. Of the three groups of people exposed to radioactive materials on aircraft, pilots, stewardesses, and passengers, the stewardesses receive the highest exposure and the pilots the smallest. For all groups, the exposure of radiation from a radioactive package was smaller than both the cosmic radiation received during a flight and the natural background radiation received on earth. As a result of this study, the Atomic Energy Commission has submitted recommendations for radioactive materials in passenger aircraft.[125] The new recommendations would cut the average radiation exposure to all groups by 25%.

For completeness, the list of hazardous materials must also include disinfectants used on aircraft and pesticides used on the airport grounds. A number of studies have been completed on a method of disinfection for aircraft using DDVP as the insecticidal agent.[126,127] The results indicate that the maximum exposure a crew member could receive will not result in any physiological function changes. However, a doubling of both the intensity and frequency of exposure will result in a decrease of the plasma cholinesterase level. On the other hand, this was the only physiological change reported.

Pesticides used on the airport property can be harmful to the people using the facility, those living adjacent to it, and also those maintaining unsatisfactory ratings (ER and EU) are presented, following the format of EPA Manual 1640.1.[129] The method for determining whether the LO rating should be given is to ascertain that the project EIS deserves neither an ER nor an EU rating.

An airport project EIS will receive an ER rating if:

1. Ambient noise levels or ambient air quality is significantly degraded by the increase in aircraft operations allowed by the project, yet no standards are violated;

2. The increased amount of impervious surface will cause serious flooding problems downstream, and no mitigating actions (e.g., storm water retention ponds with skimming devices) are taken;

3. Rare natural resources are directly or indirectly destroyed by the project, during operation or construction, where the natural resources are not protected by federal or state regulations;

4. The project described in the statement is part of a series of proposed projects (e.g., the Airport Master Plan), and the cumulative effect of the series will have detrimental effects while the project itself will not. The separability of projects not included in the impact statement, but included in the Airport Master Plan, should be noted. The building of a runway, for example, can be completely independent from the building of any other runways, where it cannot be separated from necessary improvements in the storm water drainage system or navigational aids. In cases where no statement has been submitted for the Master Plan, but statements for projects mandated by this plan are submitted for review, the reviewer must carefully note the interdependence of projects, using forecast demand patterns and the staging of new runway and terminal facilities as input to the decision regarding cumulative effects of the projects;

5. The long-term effects of the proposed project are serious and have not been taken into account. For example, the first phases of an Airport Master Plan might be environmentally acceptable, while the second- and third-phase expansion would tax the hydrologic system or exceed noise guidelines even with improved (quieter) aircraft.

An airport project EIS will receive an EU rating if:

1. Violation of standards occurs and there is no acceptable alternative open to the agency. The existence of acceptable alternatives is crucial in this decision; judgment must be balanced by the impacts of the alternative projects;

2. Violation of standards is likely to occur during later stages of operation or in related development which hinges on the proposed project. For example, a runway might be added to relieve existing congestion. If the additional aircraft operations, beyond present day levels, allowed by this runway would contribute to violation of air pollution standards in the long term, then the project should be considered for an unsatisfactory rating;

3. The federal agency violates its own substantive environmental requirements that relate to the duties and responsibilities of EPA, such as the Airport and Airway Development Act;[130]

4. There is a violation of an EPA policy declaration.

The above criteria for the ER and EU ratings are intended to be used as guidelines rather than strict rules. The decision regarding the impact of each airport project must incorporate all the mitigating factors for that particular project. The sensitivity of the airport's environment to the changes imposed by the airport, as well as the effectiveness of mitigating measures, must be taken into account. Trade-offs between lower noise levels at the expense of greater air pollutant concentrations, or between the loss of agricultural land and the gain of airport capacity must be made for each project relative to each area.

The reviewer must also determine and rate the adequacy of the information presented in the environmental impact statement. Following the format of EPA Manual 1640.1, detailed requirements will be presented only for Category 3 (Inadequate). The other two categories are briefly described. An airport project EIS will receive a Category 1 or 2 rating if it clearly does not deserve a Category 3, as described in detail below. The further split between Category 1 and Category 2 must be based on the brief descriptions of the categories.

An airport project EIS will receive a Category 1 rating if it sets forth the environmental impacts of the proposed action, as well as alternatives reasonably available to the project or action.

An airport project EIS will receive a Category 2 rating if the EPA believes that the draft EIS does not contain sufficient information to assess fully the environmental impact of the proposed action. Based on the information submitted, however, the EPA is able to make a preliminary determination it.[128] It was found that nonchemical pesticide sprays are less harmful than chemical ones. Also, nonchemical sprays will kill only the pest insect and therefore allow its natural enemies to help check its resurgence. With chemical sprays, both the pests and their enemies are killed. Since it is believed that the pest insects in many cases immigrate faster than their natural enemies, they can reinfest an area after it has been sprayed and multiply unchecked. Therefore, the costs of using chemical sprays are more than with nonchemical sprays since applications must be provided more often.

Overall, the EIS reviewer should be aware of the types of disinfectants and pesticides that are planned for use at a particular airport. Although the transport of hazardous materials is controlled completely by regulations, the reviewer should know what improvements allow additional movements of hazardous materials, and that the regulations must be upheld when meeting the new demand.

5.0 ASSESSMENT OF OVERALL IMPACT OF AIRPORT PROJECT

5.1 EPA REVIEW POLICIES AND PROCEDURAL GUIDELINES

The statement of EPA policy regarding the assessment of the overall impact of a project, as well as the adequacy of the information presented in the environmental impact statement, is contained in EPA Manual 1640.1.[129]

The impacts of the project proposed by the sponsoring federal agency must be evaluated against standards set by federal, state, and local governments, in light of the alternatives to the proposed project. Even a clear violation of standards must be weighed against the alternatives before a rating can be made. Factors to be considered in rating the project for its environmental impact include the impact in each of the areas discussed in Section 4.0, and the impact of the project in conjunction with related actions by the same agency (e.g., effect of airport construction on adjacent highways) and with related actions by other agencies (e.g., effect of airport construction on Corps of Engineers flood control programs). In the dimension of environmental impact, the project can be rated LO (lack of objection), ER (environmental reservations), or EU (environmentally unsatisfactory).

The second dimension of the review involves the adequacy of the information presented in the environmental impact statement. The completeness of the analysis presented is judged here. In addition, the reviewer must assess whether all potentially significant impacts have been investigated and presented for review in the statement. If a project is one of a series, for example, the interactive and cumulative effects of the series of projects on the environment must be discussed for all the projects. The possible ratings in the dimension of adequacy of information are 1 (Adequate), 2 (Insufficient Information), and 3 (Inadequate).

Given that there is sufficient information presented in the environmental impact statement for an airport project, the impact of the project can be rated. General criteria for the impact dimension ratings are presented here, specific to airport projects.

An airport project EIS will receive a LO rating if the EPA has no objections to the proposed action as described in the draft EIS or suggests only minor changes in the proposed action. Rather than delineate the requirement for the lack of objection (LO) rating, the requirements for the two of the impact on the environment (i.e., rate the EIS in the impact dimension: LO, ER, or EU). EPA then requests that the originator of the impact statement provide the information that was not included in the draft EIS.

An airport project EIS will receive a Category 3 rating if:

1. The impact statement contains insufficient information to permit even a partial review of project features, including failure to provide information permitting evaluation of primary effects or significant secondary effects, which are covered by the agency's standards, regulations, or policies. Significant secondary effects include land use changes resulting from an airport project. Examples of insufficient information include the use of modeling techniques inappropriate to the scope of the proposed project, such that the reviewer cannot determine the significance of the impacts;

2. The statement fails to adequately consider important project features that EPA believes have a significant impact on the environment. For instance, if an airport extending its runway to accommodate jets for the first time does not include information regarding the frequency and type of jet aircraft and the expected noise impact and air quality impact, the reviewer might consider a Category 3 rating for the EIS.

In general, no rating of the project's impact is done when a Category 3 rating is given. However, if the reviewer has a basis for review of the impacts, such as independent documents or on-site surveys, a rating may be established at the discretion of the principal reviewer after consultation with the Office of Federal Activities within EPA.

5.2 ALTERNATIVES TO AIRPORT PROJECTS

5.2.1 Levels of Consideration of Alternatives

Alternative projects that are intended to serve the same goal as the proposed airport project can originate from any of several levels of planning and may be beyond the scope of the agency proposing the project (i.e., FAA or DOT). In fact, the agency is required to consider alternative projects achieving the same ends but beyond the agency's authority to implement.[131] The scope of alternatives reasonably considered ranges from national policy to specific rearrangements of the physical configuration proposed in the project, and includes the option of doing nothing.

At the highest level of planning, the trade-offs between transportation and communication expenditures are made. Within transportation, decisions regarding which mode (e.g., highway, transit, air travel) will serve the demand for travel are made at this level.

The next level is the National Airport System Plan. Alternatives considered here are mode-specific projects to meet national air travel demand; that is, only solutions involving airports and aircraft are proposed at this level.

In the state or regional Airport System Plan, the alternative ways to meet the region's air travel needs, as part of a national system, are proposed. The need for airports is determined, although final locations are not chosen at this level. Dimensions of alternatives include the amount of emphasis to be given to general aviation in the region or state, the timing of additions to regional capacity, and the pattern of airport size (few large airports, many small ones, or one large, several medium-sized, and many small airports).

The Airport Master Plan represents a description of potential ultimate development for a particular airport. The staging of development projects is suggested in this plan. The airport uses this plan as a guide to needed projects, assuming the forecasted demand materializes. The Master Plan will have determined the possible runway configurations, as limited by meteorological and topographical considerations. Alternatives considered at this level reflect technological options and the expected air travel demand in the long term. The alternatives will consist of various arrangements for project staging and the use of different aircraft to meet demand. Alternative airport sites are also considered at this level of planning.

At the Project Development Plan, a myriad of physical configuration alternatives and operational alternatives are available. It is at this level that most environmental impact statements for airport projects are written. Since no impact statement has as yet been written for the National Airport System Plan or even for most Airport Master Plans, alternatives most logically considered at those levels are not presented for consideration. Thus, system level alternatives are considered in development project EIS, since these alternatives are relevant and have not been discussed at higher levels.

Should environmental impact statements be written for national, state, and airport plans, then the scope of alternatives considered for a development project will narrow considerably.

5.2.2 Evaluation of Alternatives

In nearly all instances, airport projects described in environmental impact statements are intended to increase the amount of air traffic in given areas by increasing, or introducing for the first time, airport capacity. The only exceptions to this are projects that propose the installation of the latest type of navigational aids to increase the probability of safe landings and takeoffs in any weather. Such projects are likely to redistribute but not increase air traffic. Since an increase of air traffic is the usual outcome, however, the alternatives must, in general, propose other ways to handle an increase in air traffic either at the national, regional, or intrastate level. Additionally, the alternative course of action of making no change in the existing airport configuration - "do nothing" - must be considered. If the environmental consequences of the proposed action are severe and the do-nothing alternative promises no better conditions, the alternative of discouraging air traffic might be considered. Of course, economic considerations must be balanced against such an alternative.

In considering the appropriateness of an alternative, the reviewer must judge it on two counts: whether it is feasible and whether it is prudent. A feasible alternative is one that can be done within the limits of current technology. A prudent alternative is one that meets the criteria of safety and economic efficiency constrained by social and environmental cost.[132] Thus, all the alternatives presented here are not applicable in all cases. Local circumstances will make some generally available alternatives infeasible; extreme economic or environmental costs will make others imprudent. An excellent example of this local variability is the difference in impacts of a runway extension into Jamaica Bay, New York, and one built on land near Detroit, Michigan. The range of feasible and prudent alternatives to runway expansion is extremely different in each case, due in part to the characteristics of the air traffic at each airport and in part to the area exposed to the runway (estuary vs level land).

The structure used to present alternatives in this handbook is built on the existing airport planning hierarchy. Since environmental impact statements are not currently written at all levels within the hierarchy, alternatives most easily considered at the higher levels must be discussed and assessed at the lower levels. The typical list of alternatives to a runway extension project would include 1) expand service at another airport; 2) build high speed intercity rail links; 3) extend another runway; and 4) do nothing. These alternatives cut across all the levels of planning and some are beyond the agency's range of authority. Bringing up the latter in a development project EIS meets the requirements of the CEQ guidelines,[131] but perhaps not the spirit of the National Environmental Policy Act.[133] However, until EIS are written for national and regional plans, a complete discussion of alternatives requires the presentation of all feasible and prudent alternatives regardless of the level of planning from which they originate.

A summary of the types of alternative actions appropriate to projects proposed at each of the five levels of planning and decision-making is contained in Table 9. The text below contains a more complete discussion of alternatives that are appropriate to specific projects originating at each level of planning. Note, however, that alternative project types, which are listed in Table 9 as being appropriate to national or regional decision-making, are legitimately considered in the airport development project EIS if these alternatives have not been considered elsewhere.

At the highest level of national planning, two options can be considered to satisfy demands for bringing people together: transportation and communication systems. Improved telephone service or mail delivery are, to a certain degree, substitutable for the transportation of people. A national policy decision to emphasize communication systems over transportation systems would result in significantly different environmental costs.

Alternative modes of transportation may be used to satisfy demand in any particular transportation corridor (e.g., Chicago-New York, Miami-Washington, D.C., Boston-Bangor, Maine). Aircraft serve intercity and international corridors; thus the pertinent alternative forms of transportation are rail, highway (auto, bus, and truck), and pipeline for goods

Table 9. Alternatives to All Levels of Airport Planning

Level of Consideration	Alternative Projects
1. National Policy	1. Communication systems 2. Other modes of transportation (rail, highway, pipeline)
2. National Airport System Plan	1. Expand capacity in a different region 2. Improve aircraft to lessen impacts
3. State or Regional Airport System Plan	1. Develop alternative airport locations to meet forecast demand 2. Scatter capacity at several smaller regional airports 3. Shift emphasis from general aviation to scheduled airlines 4. Postpone addition of regional capacity to a later date
4. Airport Master Plan	1. Reschedule proposed projects 2. Consider adding capacity for different kinds of aircraft (e.g., STOL craft)
5. Airport Development Project Plan	1. Operational changes to increase capacity 2. Economic incentives to shift time distribution of demand 3. Different runway configuration 4. Eliminate cargo handling
At all levels	Do nothing

transport. The competitiveness of each alternative varies, depending on the particular corridor and reason for travel. These kinds of alternatives are best dealt with at the national level, within the Department of Transportation, since the large scale, long-term commitment to the development of one mode necessary to make an efficient national system comes generally at the expense of one or more other modes.

Air Transport Alternatives. Alternatives considered from the National Airport System Plan level on down are all airport and aircraft specific. Once a need for air travel for either persons or goods is established, various ways are open to the Federal Aviation Administration or the Civil Aeronautics Board to meet or discourage that demand. The FAA, in writing the National Airport System Plan, can choose, in some cases, to emphasize one region over another for capacity improvements. Certain types of airports can be supported to the exclusion of others. For example, to eliminate some of the congestion at large regional airports, FAA could make funds available for small center-of-the-city V/STOL ports (vertical/short takeoff and landing aircraft) to service high density, short haul corridors. Alternatively, large regional airports designed to handle over 20 million annual passengers (enplaned plus deplaned) could be funded. These airports would be located far from the population center of the metropolitan area to minimize impacts and would depend on high speed ground transportation for access to the city center. Each region would need only one such airport.

The FAA also specifies engine types to be used in aircraft. By specifying the use of the cleanest, quietest engines available and promoting research and development activities to extend the current limits of aircraft body and engine technology, the impacts of air travel and airports on the environment can be significantly altered. Although the impacts of engine noise and emission characteristics and aircraft operating characteristics are felt locally, the impetus for change must come at the national level.

The Civil Aeronautics Board (CAB) can alter aviation's impact on the environment through the selection of routes authorized and the number of commercial air carriers authorized along a given route. These CAB decisions affect the number of aircraft flying into any particular airport and, therefore, the extent of the environmental impacts. Since CAB can change the routes into an airport, and thus the numbers and types of aircraft, forecasts of aviation activity used in determining expected future impact have a built-in uncertainty. This uncertainty is in addition to the unpredictability of demand for air travel. The other dimension of CAB's authority, fares and rates, also affects the impact of aviation on the environment, since the number of passengers carried and the amount of cargo hauled on aircraft depends on price to an extent. If fares were set too low, for example, increased usage of particular routes would be induced and the environmental impacts on the areas surrounding airports would likely increase. Indirect effects can also occur because of air cargo rates: recyclable materials shipped by air could become too expensive to recycle and therefore be disposed of instead of reused. CAB also has authority to allocate fuel among airlines, should the need arise. These actions have immediate impacts with respect to the distribution of local airport and aircraft environmental impacts.

A state or regional Airport System Plan proposes alternatives to meet the region's air travel needs. The needs are translated into a regional pattern for airports, including the amount of emphasis placed on general aviation and the typical airport size. The Airport System Plan should be coordinated with local land use plans, reflecting local growth priorities. A pattern of dispersed airport locations, each one rather small, could be selected. In that case, general aviation and V/STOL craft would be a significant component of regional air traffic. At the other extreme, one or two large regional airports, serving all regional air traffic, could be proposed. Alternatively, a series of airports could be located throughout the region, one fairly large and the rest decreasing in size. Scheduled air carrier services would be concentrated at the largest airports and general aviation at the smaller airports. The appropriateness of each alternative arrangement depends on the characteristics of both regional demand for air travel and the sensitivity of the area surrounding potential or existing airport locations. Once the need for airports in the region is established, potential locations are identified in the regional plan. Final site selection occurs at the Airport Master Plan.

The selection of the regional airport configuration reflects economic, environmental and safety constraints. An environmental impact statement written at this level in the planning process would examine the distributional effects of the alternative schemes for the regional airport system on the human and natural subsystems. Note that it is at this level that the decision concerning which airport in the region is to expand at a particular time is most logically made. Although the alternative "to expand service at another airport" is invariably considered at the Airport Development Project level, the impacts of alternative regional expansion schemes are best analyzed at the Regional Airport System Plan level.

Another variable that is controlled at the regional planning level is the timing of expansion. Expansion can be put off in the expectation that improved technology in the future will either lessen the impacts or carry more passengers without further construction, or both. Included in this aspect is the do-nothing alternative. Regional planning could call for no change in the existing airport system, except for operational changes such as improved instrument flight control devices and alternative holding patterns. Airports causing severe negative impacts on the surrounding areas might consider discouraging air traffic, if the economic disbenefits of lower levels of air transportation service do not outweigh the benefits to the airport's neighbors.

The Airport Master Plan deals with one particular airport. As part of a master plan study, the best location for the airport will be selected and the ultimate runway configuration will be prepared. The initial development projects are outlined and scheduled. Long-term growth is planned also, with suggestions as to timing of large-scale construction and land acquisition. Dimensions of alternatives to be considered at this level include site selection, timing of projects, and the type of aircraft to build for. Each potential site must be analyzed with respect to environmental impacts in addition to an economic analysis. The timing of the additions to the airport's capacity can affect the impact of the airport on the environment. If additions are made early, and the demand never materializes, the environmental costs, including disruption to the local hydrology, will never be balanced by any economic benefit. Runway extensions could be done before new runways are built to gradually increase capacity.

At this level of planning, the airport must specify the types of aircraft it will be prepared to receive and at what stages of airport development the aircraft are expected. For example, if the airport expects to handle business jets or scheduled airlines at a certain time in the future, projects must be staged to meet the extra needs (runway length, navigational aids, noise buffer zones) imposed by these aircraft. Helicopters and other STOL craft (short takeoff and landing) must be planned for separately, both on the land and in the air. Deciding which kinds of aircraft to build for depends on forecasts of regional growth and air traffic, and on the region's goals.

The Airport Development Project Plan describes a specific project to be undertaken in the short term (0-5 years). Most airport project EIS are written at this level. Although only specific operational and design alternatives to the immediate project should be considered at this level, higher level alternatives are inevitably discussed at this level, both by the FAA (originator of the airport project EIS) in the EIS and by the community. The planned actions are to be implemented in the immediate future when a development project is outlined. With such a specific, close-to-home action proposed, those opposing the project look for alternatives that might alleviate the problems expected from the proposed project. These alternatives are very likely to be beyond the authority of the agency proposing to expand the local airport or build a new airport. However, these higher level alternatives must be considered somewhere; if not treated at the higher levels of planning, the issues get raised where the specific actions occur. All the alternatives discussed for the previous four levels of planning (refer to Table 9) apply at this level. Once EIS are written for higher level plans, the alternatives considered in a Development Project EIS will focus sharply on the various ways to meet a specific goal, rather than evaluating the goal. Table 10 expands the list of alternatives at the development project level.

Since most airport projects are aimed at increasing airport capacity, the general nature of the alternatives is that they suggest another way to increase capacity but at less environmental cost. The monetary cost must be reasonable; e.g., a one dBA reduction in the average sound level is not normally worth ten times the cost of the next best (one dBA louder) alternative.

If an airport is seeking to increase capacity by adding one or more new runways or significantly extending existing runways (e.g., 8,000 ft to 12,000 ft), the demand pattern must be examined. If the primary reason for

Table 10. Alternatives to Airport Development Project Plan

Airport Development Project Plan	Possible Alternatives*
1. New or extended runways	1. Improved use of existing runways through a. pricing schemes to discourage use of peak hour capacity by flights carrying few passengers b. improvement of air traffic control devices c. Separation of noncompatible aircraft [very large and very small] during peak periods 2. Extend a different runway 3. Construct a shorter new runway or change its orientation 4. Consolidate flight schedules 5. Acquire more land to lessen impacts by increased flights on adjacent areas
2. Terminal and other related airport buildings	1. Different terminal design using less land 2. More adaptable terminal design, allowing easy expansion in the future 3. Eliminate function from airport (e.g., cargo, general aviation, scheduled airlines) 4. Make better use of existing buildings by reorganizing uses
3. Ground transportation and related parking	1. Provide mass transit access instead of private auto access 2. Improve within-airport travel so that parking may be centralized or few mass transit terminals will be needed
4. Land acquisition	1. Acquire a less sensitive piece of land, with respect to agricultural potential or the ecology.

*In all cases, the do-nothing alternative must be considered.

expansion is to relieve peak period congestion, which is significantly worse than the rest of the day, then the peak period users should be identified. If, for example, an increase in general aviation operations at an airport serving both general aviation and air carriers is expected to account for most of the congestion and, therefore, the need for the extension, than an analysis of the cost of delay should be done. Such an analysis might show that peak hour capacity of the airport is underpriced with respect to delay costs imposed on other users. A study like this done at John F. Kennedy International Airport in 1970 found that operational changes (an adjustment in peak hour landing fees for general aviation plus consolidation of scheduled airline flights) would effectively increase airport capacity more than a new runway would.[134]

Other alternatives to construction or extension of a runway include the selection of which runway to extend or where to place a new runway. For example, a general aviation airport with two 3500 ft runways, wishing to accommodate business jets, could either add a new 5000 ft runway or extend one of the two existing runways. The amount of current general aviation flights that shift from piston engine to jet aircraft, as well as additional jet flights anticipated at the expanded airport, must be considered in deciding which of the two alternatives is better. Another way to expand the airport by adding runway capacity, yet lessen the environmental impact, is to acquire more land. Then the airport can control the impact induced by increased air traffic. This is particularly important where noise is a problem. To a certain extent, air quality and ecological impacts might also be lessened, depending on the condition in which the acquired land is kept.

Finally, the do-nothing option must also be considered. Ordinarily, it is the base condition against which all other alternatives are compared. In predicting future impacts of the existing airport with no further development, the assumed demand must be examined. Generally, aviation demand is forecast without regard to limitations of supply. In some instances, the forecast demand could not possibly be served if the airport were not expanded. Impact assessment, which assumes that the high level of demand will be met, may be misleading in that the impacts of "do-nothing" will appear to be more severe than they might be on account of capacity limitations. Demand would either have to shift to another destination or never materialize because of the lack of supply.

Other airport development projects and specific alternatives are listed in Table 10. The most significant option for these projects and others listed in Table 3, items 7-12, is the do-nothing option when each project is done singly. An exception to this is where the addition of navigational aids, usually done on airport property, requires dredging and filling in an adjacent body of water. Airports located close to an ocean occasionally propose such projects.[135] A case like that requires special analysis; all mitigating effects of improved air traffic control must be weighed against potential environmental damage to the body of water.

APPENDIX A

STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS[136]

State	Environmental Impact Statement Requirement and/or Proposals	Contact
Alabama	None	Edwin G. Hudspeth Policy Studies Division Alabama Development Office State Office Building Montgomery, AL 36104
Alaska	None. However, Department of Environmental Conservation reviews projects which have "potential for environmental impact" and submits comments to appropriate agencies.	Jerry Reinwand Special Assistant to Commissioner Department of Environmental Conservation Pouch O Juneau, AK 99801
Arizona	No general requirement. Game and Fish Commission on July 2, 1971 adapted a policy requiring Game and Fish Department to prepare impact statements on proposed water-oriented development projects. Conservationists have proposed a State policy act similar to California's.	Robert D. Curtis, Chief Wildlife Planning and Development Division Arizona Game and Fish Department 2222 W. Greenway Road Phoenix, AZ 85023
Arkansas	None	Harold E. Alexander Special Advisor, Env'l Affairs Arkansas Department of Planning Game and Fish Building Little Rock, AR 72201

STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

State	Environmental Impact Statement Requirement and/or Proposals	Contact
California	California Environmental Quality Act of 1970 (Cal. Pub. Res. Code Secs. 21000-21174).	Norman E. Hill, Special Assistant to the Secretary for Resources The Resources Agency 1416 Ninth Street Sacramento, CA 95815
Colorado	No current requirement. A proposed Colorado Environmental Policy Act (Senate Bill 43, 1973 Sess.) would require an EIS on public and private actions approved by any unit of State or local government.	David F. Morrissey Assistant Director Colorado Legislative Council 46 State Capitol Denver, CO 80203
Connecticut	Executive Order No. 16, October 4, 1972 is currently in force. The Connecticut Environmental Policy Act (Pub. Act No. 73-562), approved in 1973, will not take effect until February 1, 1975.	George Russell, Director Education Programs Department of Environmental Protection State Office Building Hartford, CT 06115
Delaware	No general requirement and none proposed. Under the Delaware Coastal Zone Act (Del. Code Ann. tit. 7, Secs. 7001 et seq.), applicants for coastal zone permits must submit an EIS on proposed manufacturing projects.	John Sherman, Chief Coastal Zone Management Delaware State Planning Office 530 S. duPont Highway Dover, DE 19901

STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

State	Environmental Impact Statement Requirement and/or Proposals	Contact
District of Columbia	No current requirements. A proposal to require an EIS for "major construction projects" is under consideration.	Malcolm C. Hope, Director Office of Environmental Planning Department of Environmental Service 415 12th Street, N.W. Washington, DC 20004
Florida	No requirement. A bill similar to NEPA was introduced in the 1972 session of the Legislature, but failed to pass.	James K. Lewis, Director of Staff Committee on Environmental Pollution Control Florida House of Representatives 217 Holland Building Tallahassee, FL 32304
Georgia	No general requirement. Impact statements are required, however, for projects proposed to be undertaken by the Georgia Tollways Authority. The Office of Planning and Research, Department of Natural Resources, is considering drafting legislation to require an EIS for certain state and local actions.	James T. McIntyre, Director Office of Planning and Budget Executive Department 270 Washington Street, S.W. Atlanta, GA 30334
Hawaii	Executive Order, August 23, 1971. Nine bills to give the requirement a statutory basis were introduced in the 1973 Legislature, but only one was reported from committee (House Bill 1522): the Temporary Commission for Statewide Environmental Policy Act, including an EIS requirement applicable to private projects and local actions.	Richard E. Maryland Interim Director Office of Environmental Quality Control, Office of the Governor 550 Halekauwila Street, Rm 301 Honolulu, HI 96813

STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

State	Environmental Impact Statement Requirement and/or Proposals	Contact
Idaho	None	Glenn W. Nichols, Director State Planning and Community Affairs Agency State House Boise, ID 83707
Illinois	No requirement. Governor Richard B. Ogilvie proposed legislation similar to NEPA in 1972, but it failed to pass.	Michael Schneiderman, Director Institute for Environmental Quality 309 W. Washington Street Chicago, IL 60606
Indiana	Public Law 98, 1972 (Ind. Code 13-1-10). Not yet implemented.	Ralph C. Pickard, Technical Sec'y Environmental Management Board 1330 W. Michigan Street Indianapolis, IN 46206
Iowa	No requirement. There has been "considerable discussion" among State officials of an EIS requirement, but it appears unlikely that the Legislature will take any action in the near future.	Peter R. Hamlin Environmental Coordinator Office of Planning and Programming 523 E. 12th Street Des Moines, IA 50319
Kansas	None	John P. Halligan, Director Planning Division Department of Economic Development State Office Building Topeka, KS 66612

STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

State	Environmental Impact Statement Requirement and/or Proposals	Contact
Kentucky	None	Bernard T. Carter Executive Assistant Department of Natural Resources Frankfort, KY 40601
Louisiana	No requirement. Legislation to establish a general EIS program (House Bill 1150) was defeated in the 1972 Session of the Legislature.	Eddie L. Schwertz, Jr. Assistant Director Office of State Planning P.O. Box 44425 Baton Rouge, LA 70804
Maine	None. There was some interest among conservationists in introducing a bill in the 1973 Session of the Legislature but this legislation did not materialize.	William R. Adams, Jr. Commissioner Department of Environmental Protection Augusta, ME 04330
Maryland	Maryland Environmental Policy Act (Md. Ann. Code art. 41, Secs. 447-453), approved in 1973.	Vladimir Wahbe Secretary of State Planning 301 W. Preston St. Baltimore, MD 21201
Massachusetts	Mass. Gen. Laws Ann. ch. 30, Secs. 61-62	Harley F. Laing, Legal Counsel Exec. Office of Environmental Affairs 18 Tremont St. Boston, MA 02408

STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

State	Environmental Impact Statement Requirement and/or Proposals	Contact
Michigan	Executive Order 1973-9.	Terry L. Yonker, Executive Sec'y Environmental Review Board Department of Management and Budget Lansing, MI 48913
Minnesota	Chapt. 412, Laws 1973.	Joseph E. Sizer, Director Environmental Planning State Planning Agency 802 Capitol Square Building St. Paul, MN 55101
Mississippi	None. A proposal to create a coastal zone management program, including EIS requirements, died in the 1973 Session of the Legislature.	Edward A. May, Jr., Assistant to the Coordinator Federal-State Programs Office of the Governor 510 Lamar Life Building Jackson, MS 39201
Missouri	No requirement. Two bills similar to NEPA were introduced in the 1972 Session of the General Assembly; both died in committee. The State administration has created an Environmental Impact Statement Task Force to evaluate other State policy acts and make recommendations.	R. Brinkworth Chief Planning Specialist Comprehensive Health Planning Department of Community Affairs 505 Missouri Blvd. Jefferson City, MO 65101
Montana	Montana Environmental Policy Act (Mont. Rev. Codes Ann. Secs. 69-6501 et seq.), 1971.	Fletcher E. Newby Executive Director Environmental Quality Council Capitol Station Helena, MT 59601

STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

State	Environmental Impact Statement Requirement and/or Proposals	Contact
Nebraska	No general requirement and none proposed. Department of Roads prepares impact statements on State-funded highway projects.	Robert D. Kuzelka Comprehensive Planning Coordinator Office of Planning and Programming Box 94601, State Capitol Lincoln, NB 68509
Nevada	Complex source regulations requiring impact statement, per Nevada Revised Statutes, Ch. 445; Legislative revisions pending 5/75.	Ernest Gregory, Director Bureau of Environmental Health 1209 Johnson Street Carson City, NV 89701
New Hampshire	No requirement. Requiring impact statements on major land developments, whether private or public, is one of the priorities of a legislative coalition formed by the State's major environmental groups (contact: Miriam Jackson, Counsel, SPACE, P.O. Box 757, Concord, NH 03301).	Raymond P. Gerbi, Jr. Assistant to the Director of Comprehensive Planning Office of the Governor Concord, NH 03301
New Jersey	No general requirement. Legislation is being prepared in both houses of the Legislature. A special EIS procedure applies to a 35-mile extension of the New Jersey Turnpike. The Department of Environmental Protection has prepared guidelines for an	Alfred T. Guido Special Assistant to the Commissioner Dept. of Environmental Protection Trenton, NJ 08625

State	Environmental Impact Statement Requirement and/or Proposals	Contact
New Jersey Contd.	environmental impact procedure and distributed copies to local agencies for their guidance. In addition, the Department is "suggesting" that such assessments be made on major industrial construction projects prior to issuance of air or water pollution permits. Several local jurisdiction require an EIS as part of the zoning and subdivision process.	
New Mexico	Environmental Quality Control Act (N.M. Stat. Ann. Secs. 12-20-1 et seq.). The EIS requirement in the law has been suspended.	David W. King State Planning Officer State Planning Office Santa Fe, NM 87501
New York	No general requirement. An administration regulation (Budget Research Manual, Item 73) requires environmental review and clearance for State-funded capital construction projects. A bill for a State environmental policy Act, which included an EIS requirement, passed both houses of the Legislature in 1972 (Assembly Bill 9245-A), but was vetoed by Governor Rockefeller, who said that it would duplicate existing requirements, confuse responsibility among State agencies, and increase expenditures "at a time of protracted fiscal difficulty."	Terence P. Curran Director of Environmental Analysis Department of Environmental Conservation Albany, NY 12201

STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

State	Environmental Impact Statement Requirement and/or Proposals	Contact
North Carolina	North Carolina Environmental Policy Act (N.C. Gen. Stat. Secs. 113A et seq.), 1971.	Arthur W. Cooper, Assistant Sec'y for Resource Management Department of Natural and Economic Resources P.O. Box 27687 Raleigh, NC 27611
North Dakota	No general requirement and none pending. A special EIS procedure applies to certain wastewater treatment facilities.	Norman L. Peterson, Director Div. of Water Supply and Pollution Control Department of Health State Capitol Bismarck, ND 58501
Ohio	No requirement. Governor John J. Gilligan has requested his executive department to institute an EIS program. Bills have been drafted for a State environmental policy act, but no action is expected in the near future.	Alan L. Farkas Deputy Director for Policy Development Ohio Environmental Protection Agency 450 E. Town Street Columbus, OH 43216
Oklahoma	None	Don N. Strain, Director State Grant-in-Aid Clearinghouse Office of Community Affairs and Planning 4901 Lincoln Blvd. Oklahoma City, OK 73105

State	Environmental Impact Statement Requirement and/or Proposals	Contact
Oregon	No requirement. Bills for a State environmental protection act, including broad EIS requirements, were introduced in 1971 (Senate Bill 49) and 1973 (House Bill 2921), but not enacted. The potential cost involved was reportedly a significant factor in their defeat. Governor Tom McCall supports the concept.	Kessler R. Cannon Assistant to the Governor, Natural Resources State Capitol Salem, OR 97310
Pennsylvania	None	Thomas Dolan, Chairman Citizens' Advisory Council Dept. of Environmental Resources c/o EPIC 313 S. 16th Street Philadelphia, PA 19102
Puerto Rico	Public Environmental Policy Act (P.R. Laws Ann. title 12, Secs. 1121 et seq.), 1970.	Santos Rohena Betancourt Acting Executive Director Environmental Quality Board 1550 Ponce de Leon Ave., 4th Fl. Santurce, PR 00910
Rhode Island	No requirement. A bill to create a general EIS program was introduced in the 1972 Session of the Legislature (H 5179), but was not reported from committee.	Daniel W. Varin, Chief Statewide Planning Department of Administration 265 Melrose Street Providence, RI 02907

STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

State	Environmental Impact Statement Requirement and/or Proposals	Contact
South Carolina	No requirement. A bill to require EIS review for major private and public projects has been introduced in the 1973 Session of the Legislature.	Glen Boles, Principal Planner, Environmental Policy Office of Planning Division of Administration Columbia, SC 29211
South Dakota	None	D. R. Hood, Program Administrator Land Use Planning State Planning Agency Officer of the Governor Pierre, SD 57501
Tennessee	No requirement. Governor Winfield Dunn's administration has been considering proposing an act similar to NEPA; no decision has been taken.	Shelley Stiles Policy Planning Staff Office of the Governor 1025 Andrew Jackson Bldg. Nashville, TN 37219
Texas	"Policy for the Environment"	Ed Grisham, Director Division of Planning Coordination Box 12428, Capitol Station Austin, TX 78711
Utah	No requirement. A bill to require an EIS on State agency projects failed to reach the floor of the Legislature in 1973. The state planning office is preparing an executive order which is expected to be implemented before the end of this year	Grover Thompson Office of the State Planning Coordinator 118 State Capitol Salt Lake City, UT 84114

State	Environmental Impact Statement Requirement and/or Proposals	Contact
Vermont	None. While under Act 250 (Vt. Stat. Ann. titl 10, ch. 151) proposals for projects involving significant changes in land use require scrutiny as to environmental impact, no formal written document similar to an EIS is necessary.	Schuyler Jackson Assistant Secretary Agency of Environmental Conservation Montpelier, VT 05602
Virginia	Virginia Environmental Policy Act (Chap. 384, Acts 1973).	Robert H. Kirby, Director Division of State Planning and Community Affairs 1010 James Madison Building Richmond, VA 23219
Washington	Impact statements are required under the State Environmental Policy Act (Wash. Rev. Code Ann. ch. 43.21C), and the Highway Construction Environmental Review Law (Wash. Rev. Code Ann. Secs. 47.04,110-47.04.130), both enacted in 1971. While it does not require an EIS, the Shoreline Management Act of 1971 (Chap. 286, Laws 1971) is administered to "frequently require" impact statements to accompany the review of shoreline permits sanctioned by local officials.	Dennis L. Lundblad Office of Planning and Program Development Department of Ecology Olympia, WA 98504
West Virginia	None	Ira S. Latimer, Director Department of Natural Resources Charleston, WV 25305

STATE ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

State	Environmental Impact Statement Requirement and/or Proposals	Contact
Wisconsin	Wisconsin Environmental Policy Act (Wis. Stat. Sec. 11.1; Chap. 274, Laws 1971), and Wis. Stat. Secs. 23.11(5), 30.10(4), and 31.06(3); Chap. 273, Laws 1971.	L. P. Voigt, Secretary Department of Natural Resources P.O. Box 450 Madison, WI 53701
Wyoming	None	Vincent J. Horn, Jr. Admin. Assistant to the Governor Capitol Building Cheyenne, WY 82001

APPENDIX B. HAND METHOD FOR THE CALCULATION OF AIR POLLUTANT CONCENTRATION LEVELS

The Western Region of the FAA has developed a box model for use in dispersing pollutants to predict air quality.[137] The following calculation parameters are used in the model:

1. Landing-takeoff cycles (LTO) are calculated for "peak-hour" operation;

2. It is assumed that there is no wind dispersal, settling, or mixing of pollutants beyond the boundaries of the closed box.

3. An LTO cycle is considered to include all normal operational modes performed by an aircraft between the time it descends through an altitude of 1100 meters on its approach and the time it subsequently reaches the 1100-meter altitude after takeoff. It must be remembered that the term "operation" as used by FAA to describe either a takeoff or landing is not the same as an LTO cycle. An LTO cycle incorporates the ground operations of idle, taxi, landing run, takeoff role, and flight operations of departure from ground to 1100 meters and approach from 1100 meters to touchdown.

To determine concentrations, the number of peak-hour LTO cycles by aircraft type listed in Table B-1 are predicted. Remember that 1 LTO cycle includes 2 aircraft operations. Therefore, 100 peak-hour operations equals 50 LTO cycles. Once the LTO cycles are available, Table B-1 is used to calculate the total concentration of a given pollutant for all types of aircraft.

The information compiled in Table B-1 is based on two sources. First, the emission factors are found in the U.S. EPA document AP-42.[138] The volume of the box is defined by the Western Region report, with the dimensions defined in Table B-2. Given the emission factors and the volume of the box, the concentrations per LTO cycle by aircraft are calculated (and may be found in Table B-1).

The depth used in Table B-2 (1100 meters) is not representative of the "worst-case" condition.[139] Typically, 100 meters would be used. Unfortunately, the emission factors include an LTO cycle that begins and ends at an elevation of 1100 meters. Therefore, if the depth of the box is lowered to 100 meters, the emission levels are too high due to the inclusion of emissions between 100 and 1100 meters.

Table B-1. Concentrations/Peak Hour Aircraft LTO Cycle

Aircraft	No. of Engines	Particulates $\mu g/m^3$	Sulfur Oxides $\mu g/m^3$	Carbon Monoxide mg/m^3	Hydrocarbons $\mu g/m^3$	Nitrogen Oxides $\mu g/m^3$
Jumbo	4	0.058	0.082	0.0021	0.541	1.397
Jet	3	0.044	0.061	0.0016	0.406	1.048
Long-range	4	0.054	0.069	0.0021	1.839	0.354
Jet	3	0.041	0.052	0.0015	1.379	0.266
Medium-range	4	0.019	0.045	0.0007	0.216	0.453
Jet	3	0.014	0.034	0.0006	0.162	0.339
	2	0.009	0.023	0.0004	0.108	0.226
Business	4	0.015	0.049	0.002	0.463	0.212
Jet	2	0.008	0.025	0.001	0.231	0.106
Air Carrier	4	0.049	0.018	0.0003	0.132	0.112
Turboprop	2	0.024	0.009	0.0002	0.066	0.056
Gen. Aviation Turboprop	2	0.005	0.004	0.0001	0.025	0.027
Air Carrier	4	0.019	0.010	0.010	1.369	0.013
Piston	2	0.009	0.005	0.005	0.685	0.007
Gen. Aviation	2	0.0004	0.0002	0.0002	0.007	0.0009
Piston	1	0.0002	0.0001	0.0001	0.004	0.0005

Table B-2. Dimensions of Closed Box Model

Type Aircraft	Length	Meters Width	Depth	Volume Meters
Jumbo Jet	23,100	1,600	1,100	$40,656 \times 10^6$
Long-range Jet	"	"	"	"
Medium-range Jet	"	"	"	"
Business Jet	7,800	"	"	$13,728 \times 10^6$
Air Carrier Turboprop	22,500	"	"	$39,600 \times 10^6$
Gen. Aviation Turboprop	"	"	"	"
Air Carrier Piston	30,700	"	"	$54,032 \times 10^6$
Gen. Aviation Piston	27,600	"	"	$48,600 \times 10^6$

One option for modifying the model for a depth of 100 meters is to determine the amount of pollutants emitted between 100 and 1100 meters and subtract that from the emission rates. A new box volume can be determined by substituting 100 for the 1100-meter depth in Table B-2. With the new volume, a new set of concentrations may be calculated by dividing it into the new emission values.

It is difficult to determine what percent of the takeoff and approach emissions are generated between 100 and 1100 meters. Therefore, a conservative estimate may be calculated by simply assuming that the same emissions are generated into the smaller box. This value may be determined by simply multiplying the final concentration for each pollutant by 10.

As an example, the peak-hour CO concentration will be calculated assuming the following peak-hour LTO's:

3 - Jumbo Jets (4 engine)
3 - Long Range Jets (4 engine)
5 - Medium-range Jets (2 engine)
5 - Business Jets (2 engine)
4 - General Aviation Turboprops (2 engine)
15 - General Aviation Piston (1 engine)
6 - General Aviation Piston (2 engine)

By multiplying the concentrations found in Table B-1 by the above LTO cycles, the following CO concentrations are found

Jumbo Jets (4 engine) -	0.0063 mg/m^3
Long-range Jets (4 engine) -	0.0063
Medium-range Jets (2 engine)	.0020
Business Jets (2 engine) -	.0050
General Aviation Turboprops (2 engine) -	.0004
Gen. Aviation Piston (1 engine) -	.0015
Gen. Aviation Piston (2 engine) -	.0012
Total Peak-Hour CO Concentration	0.0227 mg/m^3

To calculate the conservative estimate, multiply this figure by 10; this results in a concentration of 0.227 mg/m^3. When comparing with the National Ambient Air Quality Standard (Table 7, Sec. 5.4) of 40 mg/m^3 for the 1-hr CO concentration, one concludes that the emissions generated by the aircraft activity are well within the standards. To be complete, the concentration for each pollutant generated by the total LTO cycles must be added to the ambient level before being compared to the standards.

Although Table B-1 is constructed for use with peak-hour LTOs, not all of the air standards are 1-hr standards. Some of the standards are written for 8-hr periods and others for 24-hrs. Nevertheless, Table B-1 can be used for determining the concentration for any pollutants, regardless of the time period. If the standard is an 8-hr one, simply estimate the LTOs for the 8-hr period and multiply this number by the contents of Table B-1. The same philosophy applies to the remaining standards.

APPENDIX C. HAND METHOD FOR THE CALCULATION OF NOISE LEVELS[140]

A rough estimate of NEF contours can be made by following the procedure developed by the U.S. Department of Housing and Urban Development (HUD). A study was made of twenty airports (averaging from one to over one thousand jet aircraft operations per day) to determine the relationship between the NEF-30 and NEF-40 contours and the number of jet aircraft operations per day (and night). The HUD procedure tends to give a conservative estimate of the noise exposure.

The following information is required from the FAA Control Tower or the Airport Operator:

1. Number of nighttime jet operations (10:00 P.M. - 7:00 A.M.);
2. Number of daytime jet operations (7:00 A.M. - 10:00 P.M.);
3. Supersonic jet operations;
4. Flight paths of the major runways;
5. Expected changes in airport traffic - e.g., will the number of operations increase or decrease in the next ten or fifteen years? Are there any plans for supersonic jet traffic?
6. Approved plans for runway changes (extensions or new runways).

Once the required information has been obtained, the effective number of airport operations is determined. First, multiply the number of nighttime jet operations by 17. Next, add to this the number of daytime jet operations to find the effective number of operations. Any supersonic jet operation automatically places an airport in the largest category of Table C-1, which governs noise acceptability.

On a map of the area under consideration, which shows the principal runways, mark the location of the airport site and of the center of the area covered by the principal runways. Then, using the distances given in Table C-1 relative to the number of effective operations, construct approximate NEF-30 and NEF-40 contours for the major runway and flight paths most likely to affect the site. Figure C-1 will aid the reviewer in the proper construction of the estimated contours.

Table C-1. Distances for Approximate NEF Contours

Effective Number of Operations	Distances to NEF 30 Contour 1	Distances to NEF 30 Contour 2	Distances to NEF 40 Contour 1	Distances to NEF 40 Contour 2
0 - 50	1000 ft	1 mile	0	0
51 - 500	1/2 mile	3 miles	1000 ft	1 mile
501 -1300	1 1/2 miles	6 miles	2000 ft	2 1/2 miles
More than 1300 or any supersonic jet operations	2 miles	10 miles	3000 ft	4 miles

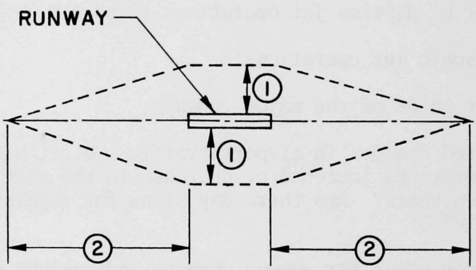

Fig. C-1. Construction of Approximately NEF Contours Using the Distances in Table C-1

Through the use of this hand method, the reviewer may determine the approximate locations of the NEF 30 and 40 contours for a given airport. This information can then be compared to the noise analysis found in the EIS under review, or be used in lieu of a noise analysis if the noise analysis provided is incomplete or nonexistent.

APPENDIX D. REVIEW OF SELECTED STORMWATER RUNOFF MODELS

Only three models will be described in this section. The variations in existing models are many and detailed, precluding the selection of representative models. Instead, three models that are appropriate to planning purposes, easily available, likely to be used, and somewhat different from each other with respect to cost, authorship, and data required have been selected. The selection of a model for description in this section does not constitute a recommendation for its use; neither does being overlooked in this section condemn a model. These three models are selected to give the reviewer an idea of what to expect in stormwater runoff models. A reviewer who will be examining many EISs for their water impact analyses is well advised to become familiar with several models, at least to the level of detail presented in the references mentioned below. There is currently much discussion in the literature regarding the usefulness of the many models available. Articles such as the one by Heeps and Mein[141] present quantitative comparisons of the most current models, although no statistical measures of fit are provided. Brandstetter[88] has reviewed 18 computerized runoff models, seven of which he ran on similar data sets for quantitative comparison of results. Linsley has summarized several water runoff models with criticism on both the theory upon which the model is based and the ease of use.[142] The Hydrologic Engineering Center of the Army Corps of Engineers has prepared an excellent summary of the state of the art in hydrology models, including complete descriptions of a wide selection of models.[87]

For the analysis of the impact of an airport project, it is not always appropriate to use a large-scale computer simulation model of runoff. A very small airport will often show no appreciable effect; therefore, general trends in land use change are better modeled at a regional level, or perhaps at the county level. A proposal for a very large airport, such as Dallas-Fort Worth Airport or the proposed Palmdale Intercontinental Airport near Los Angeles, must surely include an analysis of its impact on water flow using a large-scale computer model. The cutoff between "very small" and "very large," to determine a general rule for the applicability of computer simulation models, is difficult to establish. The cost of the project is one indicator; the benefit of using an expensive computer program to model the effect of one 4000-ft runway is probably negative, though there is much to be gained from such an effort when planning a 10,000-acre multi-runway airport. The sensitivity of the area to additional development, including the urbanization that usually follows an airport, must also be considered in deciding the need for modeling.

The three models described here are the Urban Storm Water Runoff Model (STORM) by the Army Corps of Engineers; the Storm Water Management Model (SWMM) by the U.S. Environmental Protection Agency; and the Hydrologic Simulation Program (HSP), a proprietary model of Hydrocomp International, Inc. All three require computer facilities.

STORM, the Hydrologic Engineering Center of the Corps of Engineers,[90] is a relatively recent, generally available, planning model. It is general in scope and does not consider routing of flow but does process continuous hourly precipitation data from several years. Both quality and quantity are modeled. The input to the program includes:

1. Hourly precipitation data and mean temperatures for as many years as desired, available from the National Weather Service on magnetic tape;

2. Normal annual precipitation for the watershed and the precipitation station;

3. Surface depression storage for urban and non-urban portions of watershed;

4. Runoff coefficients, urban/nonurban;

5. Potential evaporation in inches per day for each month for the urban and nonurban;

6. Land use: five categories for each watershed, including percent impervious for each land-use category, density of street gutters, and frequency of street sweeping;

7. Water quality data, if available.

The output of the program includes quantity analysis, quality analysis, and a detailed hourly record for selected events. This model allows analysis of storage and treatment options for runoff water for moderate-sized watersheds. The primary weak point of the model is its use of a modified rational formula for use in predicting the amount of runoff.

The Storm Water Management Model (SWMM) by EPA[143] is more detailed and costly to run than STORM. The quality analysis is extremely detailed. It is not a continuous model; a design storm hyetograph (rainfall intensity vs time) is input and the resulting flow pattern is output. The model is limited to fairly small, primarily urban watersheds, and the results can best be used in the design of pipe systems to store and route stormwater runoff. The input required includes:

1. Watershed characteristics such as infiltration rate, percent impervious area, slope, area, detention storage, depth, and Manning's coefficient for overland flow;
2. Rainfall hyetograph;
3. Land use data, population of subareas, and average market value of dwellings;
4. Characteristics of gutters, including slope and depth;
5. Street cleaning frequency;
6. Treatment devices and capacities;
7. *Engineering News Record* indices for cost;
8. Boundary conditions in the receiving waters;
9. Storage volume and location;
10. Inlet characteristics;
11. Characteristics of pipes, such as type, geometry and Manning's "n".

The output provided includes hydrographs (water flow vs time) at any point, and amounts and locations of local flooding. Quality data is also printed in the form of pollutographs of water quality vs time. Cost of capital, land, and operation and maintenance of selected waste treatment systems are provided in the output. According to Heeps and Mein,[141] SWMM is likely to overpredict flows in some situations. The seriousness of this over-prediction is not known, however, since validation is not completed.

The Hydrologic Simulation Program (HSP) of Hydrocomp International, Inc.,[144] is available only through Hydrocomp. It is written in the PL/1 computer language, limiting it to large IBM computers, in contrast to the two programs discussed above, which are written in the FORTRAN IV language. The program is very general and has excellent data management capabilities. It is most useful for large river basins, as the water quality modeling section is very good. The model has been used in smaller areas, however, with good results.

The input required includes one to two years of hourly precipitation data, evapotranspiration, and temperature data if snowmelt is to be considered. Output includes hourly and mean daily discharge, reservoir water levels, river stages, stream and lake temperature, monthly accretion to groundwater, end-of-month soil moisture, snow depth and water equivalent, and several water quality indicators.

In summary, most of the runoff models available can do an adequate job of estimating the changes in runoff brought about by the addition of an airport. The Stanford Watershed Model, one of the first to simulate storm-water runoff, is rapidly advancing and it is not yet clear which of the many models available will become the most useful and most used. Since validation has not been completed for any model as of this writing, results of all models must be carefully scrutinized at each application. For rough estimates of impact, the traditional Rational Method can provide adequate results.

REFERENCES

1. "National Environmental Policy Act of 1969," *Public Law 91-190* (Jan 1, 1970).

2. "Clean Air Amendments of 1970," *Public Law 91-604* (Dec 28, 1970).

3. "Preparation of Environmental Impact Statements: Guidelines," Council on Environmental Quality, *Federal Register*, *38*(147):20550 (Aug 1, 1973).

4. *Review of Federal Actions Impacting the Environment*, Manual 1640.1, U.S. EPA, Washington, D.C., being revised (Nov 30, 1972).

5. *Guidelines for Review of Environmental Impact Statements: Highway Projects*, Office of Federal Activities, U.S. EPA, Washington, D.C. (Sept 1973).

6. "Airport and Airway Development Act of 1970," *Public Law 91-258* (May 21, 1970).

7. *National Airport Classification System*, Federal Aviation Administration, U.S. Dept of Transportation, Advisory Circular 150/5090-2, Washington, D.C. (June 25, 1971).

8. *Airports and Their Environment*, Office of the Secretary, U.S. Dept. of Transportation, DOT P 5600.1, Washington, D.C. (Sept 1972).

9. *Ibid*, pp 23-24.

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